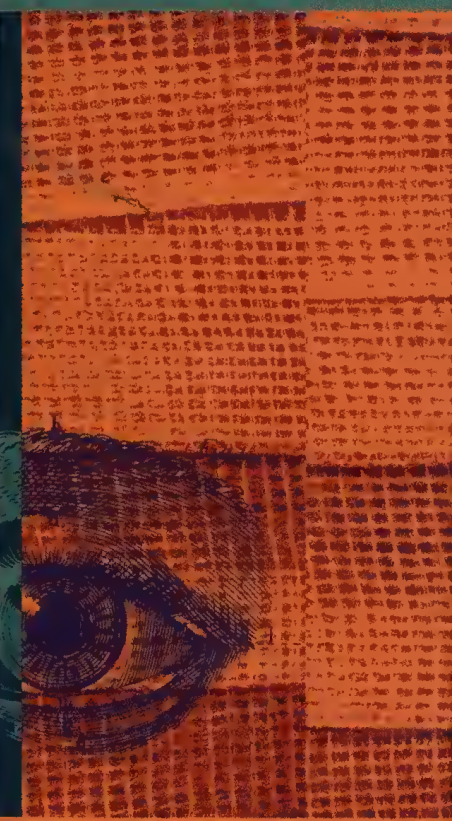
Medical Discoveries

VOLUME 3 M-Z



Medical Breakthroughs and the People Who Developed Them

Bridget Travers and
Fran Locher Freiman,

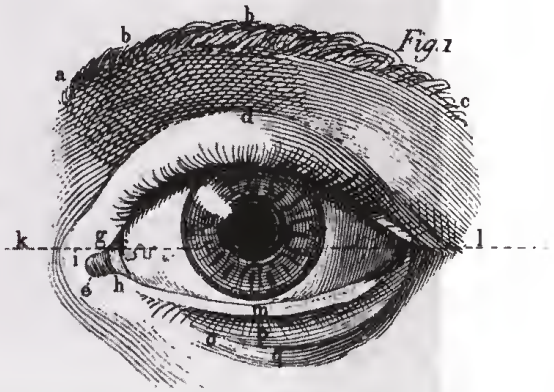
Medical Discoveries:

Medical Breakthroughs and the People Who Developed Them

Medical Discoveries:

Medical Breakthroughs and the People Who Developed Them

Volume 3: M-Z



Bridget Travers and Fran Locher Freiman, Editors

U·X·L®
AN IMPRINT OF GALE

DETROIT • NEW YORK • TORONTO • LONDON

Medical Discoveries:

Medical Breakthroughs and the People Who Developed Them

Bridget Travers and Fran Locher Freiman, Editors

Staff

Elizabeth Des Chenes, *U·X·L Developmental Editor*
Carol DeKane Nagel, *U·X·L Managing Editor*
Thomas L. Romig, *U·X·L Publisher*

Margaret Chamberlin, *Permissions Specialist (Pictures)*

Shanna P. Heilveil, *Production Associate*
Evi Seoud, *Assistant Production Manager*
Mary Beth Trimper, *Production Director*

Pamela A. E. Galbreath, *Art Director*
Cynthia Baldwin, *Product Design Manager*

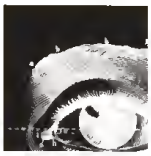
Marco Di Vita *Typesetting*

Library of Congress Cataloging-in-Publication Data
Medical discoveries: medical breakthroughs and the people who developed them/ edited by Fran Locher Freiman.
p. cm.
Includes index. Contents: Vol. 1. A-C.
ISBN 0-7876-0890-4 (set : alk. paper).— ISBN 0-7876-0891-2 (vol. 1 : alk. paper).—ISBN 0-7876-0892-0 (alk. paper).—ISBN 0-7876-0893-9 (alk. paper).
1. Medicine—History—Encyclopedias. 2. Dentistry—History—Encyclopedias. I. Freiman, Fran Locher.
R131.M396 1996
610' .9—dc20
96-42696
CIP

Printed in the United States of America

10 9 8 7 6 5 4 3 2

Table of Contents



Reader's Guide

Medical Discoveries: Medical Breakthroughs and the People Who Developed Them features 215 entries on medical and dental inventions and discoveries that have had a great impact on health throughout the world—from fluoride treatments to AIDS therapies—as well as the people responsible for them. Written in nontechnical language, *Medical Discoveries* explores medical practices such as acupuncture, significant developments in research such as chemotherapy, and instrumentation such as X-ray machines that have profoundly changed the way diseases are diagnosed and people are treated.

Each *Medical Discoveries* entry, whether on a well-known discovery or a lesser-known invention, identifies the person behind the breakthrough, explores the knowledge and technology that led to it, and explains how the advance changed the world in which we live.

Scope

Arranged alphabetically over three volumes, *Medical Discoveries*'s entries range from one-quarter to seven pages in length. Accompanying several of the entries are sidebar boxes discussing related topics and items of special interest to students, such as the discovery of DNA structure. Boldfaced terms in entry text direct the reader to related entries in the set. Cross-references at the end of an entry direct the reader to related breakthroughs and discoveries not specifically mentioned in that entry. More than 150 photographs enliven and help explain the text.

Each *Medical Discoveries* volume opens with a further readings page that guides readers to titles of similar interest, a timeline of medical and dental landmarks, and a glossary of important medical and dental terms found in the text. The volumes conclude with a comprehensive gen-

eral index, providing easy access to the people, theories, and discoveries and inventions mentioned throughout *Medical Discoveries.*

Acknowledgments

Special thanks are due for the invaluable comments and suggestions made by U·X·L's science advisors:

Marilyn S. Gilbert, Science Chair at Mondison Middle School in Madison Heights, Virginia; Melba Holland, Earth Science/Science Department Head at Slaton Junior High in Slaton, Texas; and Magi J. Terry, Science Department Head at Yearling Middle School in Okeechobee, Florida.

Comments and Suggestions

We welcome your comments on this work as well as your suggestions for topics to be featured in future editions of *Medical Discoveries: Medical Breakthroughs and the People Who Developed Them.* Please write: Editors, *Medical Discoveries,* U·X·L, 835 Penobscot Bldg., Detroit, Michigan 48226-4094; call toll-free: 1-800-877-4253; or fax 1-313-877-6348.

Further Reference

Curtis, Robert. *Great Lives: Medicine*. New York: Simon & Shuster, 1993.

Fradin, Dennis B. *Medicine: Yesterday, Today, and Tomorrow*. Chicago: Children's Press, 1989.

Graham, Ian. *Fighting Disease*. Austin, Texas: Raintree Steck-Vaughn, 1994.

Hooper, Meredith. *Germs, Jabs, and Laughing Gas: Great Medical Discoveries*. St. Albans, England: D. Bennett, 1994.

Richie, David. *Health and Medicine*. Broomall, Pennsylvania: Chelsea House, 1994.

Royston, Angela. *100 Greatest Medical Discoveries*. Limpsfield, England: Dragon's World, 1995.

Senior, Kathryn. *Medicine: Doctors, Demons, and Drugs*. New York: Orchard Books, 1995.

Wingate, Peter. *Medical Encyclopedia*. New York: Viking Penguin, 1997.

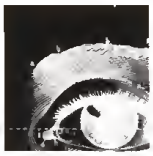


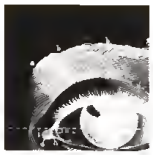
Photo Credits

The photographs appearing in *Medical Discoveries: Medical Breakthroughs and the People Who Developed Them* were received from the following sources:

Photograph by Charles Gupton. The Stock Market. Reproduced by permission.: p. 4; **Archive Photos. Reproduced by permission.:** pp. 8, 59, 64, 377, 405; **© Telegraph Colour Library/FPG International Corp. Reproduced by permission.:** pp. 11, 22; **AP/Wide World Photos. Reproduced by permission.:** pp. 12, 33, 79, 89, 95, 126, 128, 133, 160, 200, 230, 253, 262, 304, 315, 337, 339, 358, 360, 362, 397, 399, 417; **© 1992 Pete Saloutos/The Stock Market. Reproduced by permission.:** p. 16; **UPI/Corbis-Bettmann. Reproduced by permission.:** pp. 18, 262, 363; **© Will & Deni McIntyre, National Audubon Society Collection/Photo Researchers, Inc. Reproduced by permission.:** p. 27; **© Michael Siegel/Phototake NYC. Reproduced by permission.:** pp. 34, 129, 238; **© 1991 Mark Harmel/FPG International Corp. Reproduced by permission.:** pp. 37, 250; **Corbis-Bettmann. Reproduced by permission.:** pp. 43, 270; **© GCA/CNRI/Phototake NYC. Reproduced by permission.:** p. 45; **© CNRI/Phototake NYC. Reproduced by permission.:** pp. 46, 225; **© Richard Nowitz/Phototake NYC. Reproduced by permission.:** p. 48; **Phototake NYC. Reproduced by permission.:** p. 53; **© Prof. P. Motta/G. Macchiarelli University "La Sapienza," Rome/Science Photo Library, National Audubon Society Collection/ Photo Researchers, Inc. Reproduced by permission.:** p. 55; **© Ed Kashi/Phototake NYC. Reproduced by permission.:** pp. 56, 61; **© Srulik Haramaty/Phototake NYC. Reproduced by permission.:** pp. 68, 278; **© Yoav Levy/Phototake NYC. Reproduced by permission.:** pp. 72, 391; **© 1994 Stephen Simpson/FPG International Corp. Reproduced by permission.:** p. 74; **Illustration by Robert L. Wolke. Reproduced by permission.:** p. 76; **© Luis de la Maza/Phototake NYC. Reproduced by permission.:** p. 77; **Photograph by Michael Keller. The Stock Market. Reproduced by permission.:** p. 82; **© Bob Abraham/The Stock Market. Reproduced by permission.:** p. 91; **© 1993 Dale O'Dell/The Stock Market. Reproduced by permission.:** p. 97; **© 1996 Kevin Laubacher/FPG International Corp. Reproduced by permission.:** p. 100; **© David Sutton/Zuma Images/The Stock Market. Reproduced by permission.:** p. 101; **© Martin Rotker/Phototake NYC. Reproduced by permission.:** p. 105; **Courtesy of the Library of Congress.:** pp. 108, 131,

Photo Credits

137, 194, 203, 209, 228, 265, 327, 328; **© 1992 Chris Jones/The Stock Market. Reproduced by permission.:** p. 114; **© 1992 Donal Philby/FPG International Corp. Reproduced by permission.:** p. 117; **© 1990 Terry Qing/FPG International Corp. Reproduced by permission.:** pp. 123, 370; **© Brad Nelson/Phototake NYC. Reproduced by permission.:** p. 139; **© 1990 Bob Peterson/FPG International Corp. Reproduced by permission.:** p. 161; **Photograph by Randy Duchaine. The Stock Market. Reproduced by permission.:** pp. 162, 204, 422; **© 1986 Jeffrey Sylvester/FPG International Corp. Reproduced by permission.:** p. 164; **© J.C. Revy/Phototake NYC. Reproduced by permission.:** p. 166; **©Ken Wagner/Phototake NYC. Reproduced by permission.:** p. 172; **Earl Kowall/Corbis. Reproduced by permission.:** p. 177; **© 1989 Jon Feingersh/The Stock Market. Reproduced by permission.:** p. 181; **© 1992 Michael Krasowitz/FPG International Corp. Reproduced by permission.:** p. 196; **© 1994 Bill Losh/FPG International Corp. Reproduced by permission.:** p. 205; **© 1995 Michael Shay/FPG International Corp. Reproduced by permission.:** p. 207; **© 1991 Howard Sochurek/The Stock Market. Reproduced by permission.:** pp. 212, 314; **© IPRI/Phototake NYC. Reproduced by permission.:** p. 219; **© Albert Paglialunga/Phototake NYC. Reproduced by permission.:** p. 233; **National Institutes of Health/Corbis. Reproduced by permission.:** p. 236; **© Dr Dennis Kunkel/Phototake NYC. Reproduced by permission.:** p. 246; **© Joel Landau/Phototake NYC. Reproduced by permission.:** p. 256; **© 1990 Art Montes De Oca/FPG International Corp. Reproduced by permission.:** p. 278; **© 1992 Mason Morfit/FPG International Corp. Reproduced by permission.:** pp. 300, 325; **© 1989 J. Reznicki/The Stock Market. Reproduced by permission.:** p. 301; **© 1996 Ron Chapple/FPG International Corp. Reproduced by permission.:** p. 303; **© Carolina Biological Supply Company /Phototake NYC. Reproduced by permission.:** p. 305; **© 1992 B. Kramer. All rights reserved. Custom Medical Stock Photos Inc. Reproduced by permission.:** pp. 306, 322; **J.E. Stevenson/FPG International Corp. Reproduced by permission.:** p. 311; **©Account Phototake/Phototake NYC. Reproduced by permission.:** p. 317; **© 1991 Dick Luria/FPG International Corp. Reproduced by permission.:** p. 320; **©Tom Tracy/FPG International Corp. Reproduced by permission.:** p. 330; **© McCarthy, T./Custom Medical Stock Photo, Inc. Reproduced by permission.:** p. 336; **© Alexander Tsiaras/Science Source. Photo Researchers Inc. Reproduced by permission.:** p. 342; **© Bob Masini/Phototake NYC. Reproduced by permission.:** p. 347; **© Goivaux Communications/Phototake NYC. Reproduced by permission.:** p. 354; **© Ted Horowitz/The Stock Market. Reproduced by permission.:** p. 367; **© Di Maggio/Kalish/The Stock Market. Reproduced by permission.:** p. 368; **© 1992 Ed Braverman/FPG International Corp. Reproduced by permission.:** p. 381; **© 1992 Michael Tamborrino/FPG International Corp. Reproduced by permission.:** p. 384; **© 1989 Daniel Quat/FPG International Corp. Reproduced by permission.:** p. 388; **Charles and Josette Lenars/Corbis. Reproduced by permission.** p. 390; **© 1988 Thomas Craig/FPG International Corp. Reproduced by permission.:** p. 393; **© Chet Szymecki/Phototake. Reproduced by permission.:** p. 395; **© 1994 Brownie Harris/The Stock Market. Reproduced by permission.:** p. 402; **Joan Slatkin/The Stock Market. Reproduced by permission.:** p. 407; **© William D. Adams/FPG International Corp. Reproduced by permission.:** p. 412; **© 1994 David Doody/FPG International Corp. Reproduced by permission.:** p. 414; **© 1992 Guy Marche/FPG International Corp. Reproduced by permission.:** p. 424.



Timeline of Medical Events

4000 B.C.: Babylonians use opium in medical procedures.

3000 B.C.: First recorded cesarean surgeries are performed in Egypt.

762 B.C.: Wang Ping compiles an edition of the *Nei Ching*, a basic reference book on acupuncture.

700 B.C.: Etruscans construct false teeth from ivory and bone.

c. 600 B.C.: Skin graft surgery is successfully performed in India.

c. 400 B.C.: Hippocrates studies how disease is spread from person to person.

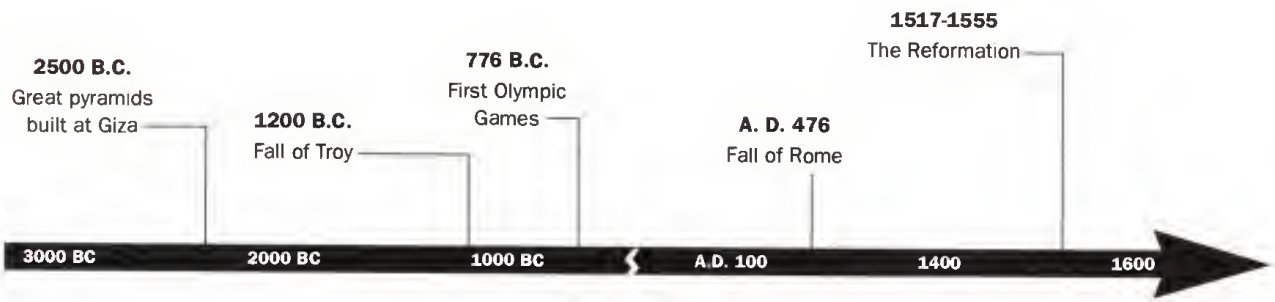
c. A.D. 160: Galen conducts extensive studies of animal anatomy.

1285: Salvino degli Armati invents eyeglasses.

1492: Pope Innocent VIII receives the first recorded blood transfusion.

1536: Surgeon Ambroise Paré designs the first artificial limbs.

1543: Anatomist Andreas Vesalius publishes his influential medical text about the human body called *De humani corporis fabrica.*



Early 1600s: Bristle-style toothbrush is introduced in Europe.

1616: Dr. William Harvey lectures about blood circulation.

1748: J. Daviel performs the first cataract operation.

1792: Dominique-Jean Larrey begins the first field ambulance service.

1796: Edward Jenner develops the smallpox vaccine.

1816: Rene Theophile Laennec invents the modern stethoscope.

1818: Humphry Davy discovers nitrous oxide, or "laughing gas."

1835: Theodor Schwann uncovers pepsin in gastric juice.

c. 1850s: Louis Pasteur develops the theory that germs cause disease by interfering with the body's biological processes.

1852: Antonius Mathijsen develops plaster of paris casts for setting fractures.

1853: Charles Pravaz invents the hypodermic syringe.

1865: Joseph Lister introduces antiseptic surgical procedures.

1866: Sir Thomas Clifford Allbutt invents the medical thermometer.

1866: Pasteurization is first used prevent wine spoilage.

1876: Siegfried von Basch invents the modern blood pressure measuring device.

1879: Listerine is introduced as a patent medicine.

1880: Gregor Mendel discovers hereditary factors in plants.

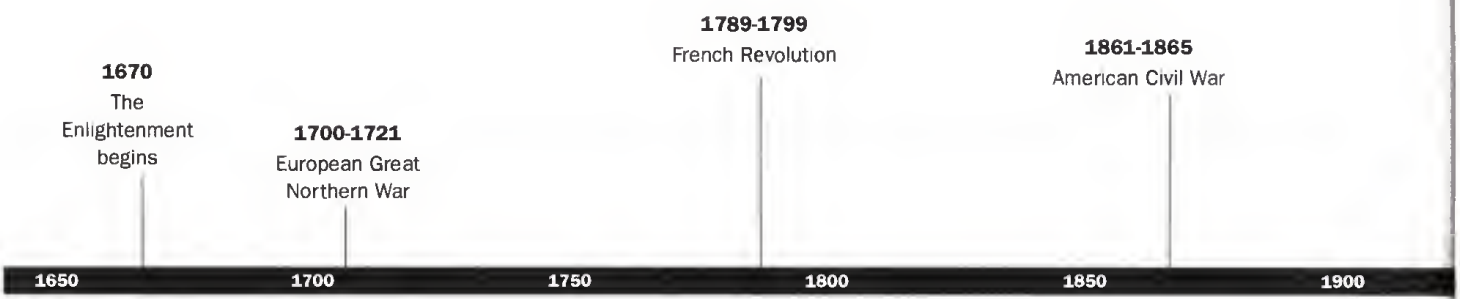
c. 1880: Elie Metchnikoff discovers the role white blood cells play in disease control.

1888: Eugene Kalt develops first contact lens.

1895: Wilhelm Roentgen discovers X-ray radiation.

1899: The Bayer Company begins producing aspirin.

1900: Karl Landsteiner discovers blood groups, or types.



1905: Ernest Starling and William Bayliss isolate secretin.

1906: Frederick Gowland Hopkins discovers vitamins.

1913: John Jacob Abel builds the first kidney dialysis machine.

1913: William Henry Bragg and his son, William Lawrence Bragg, construct the first X-ray spectroscope.

1920: Earl Dickson invents the Band-Aid.

1928: Ernst Ruska develops the electron microscope.

1931: Frederick S. McKay discovers that fluoride prevents tooth decay.

1937: Daniele Bovet and Anne-marie Staub synthesize antihistamine for allergy relief.

1938: Alexander Fleming, Howard Florey, and Ernst Chain discover penicillin.

1939: George Nicholas Papanicolau develops the pap test for detecting cervical cancer.

c. 1950: The first prenatal surgery is performed.

1952: Virginia Apgar develops a scoring system to help determine the health of newborn babies.

1953: Francis Crick and James Watson discover the structure of DNA.

1955: Radial keratotomy is first performed in Japan.

1955: Johnson & Johnson introduces Tylenol.

1957: Ian Donald tests ultrasound diagnostic instrument.

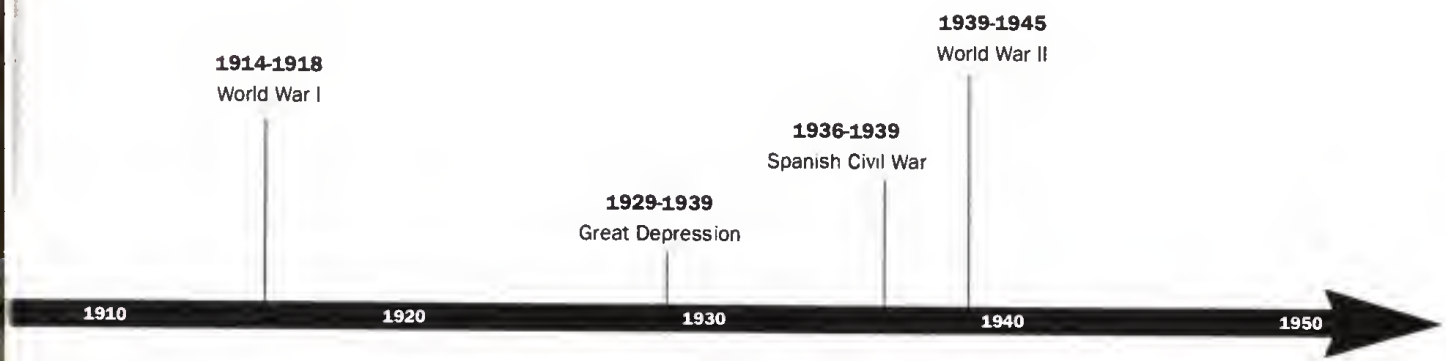
1960: Birth control pill is approved for general use.

1960: First pacemaker is implanted in a human to regulate heartbeat.

1964: Boots Laboratories begins selling ibuprofen under the brand name Brufen.

1967: Christiaan Barnard performs the first heart transplant.

c. 1967: Alan Cormack and Godfrey Hounsfield develop the computerized axial tomography (CAT) scanner.



1969: Denton Cooley implants first human artificial heart

c. 1970: Michael Phelps and Edward Hoffman develop the positron emission tomography (PET) scanner.

Early 1970s: Laser surgery techniques are perfected.

1973: Cochlear implants are used for the first time to improve hearing.

1976: The retinal scanner is developed.

1978: The first "test tube" baby is born as a result of in vitro fertilization.

c. 1981: Magnetic resonance imaging (MRI) testing is first used for diagnosing illness.

1984: Drug AZT is developed for the treatment of AIDs.

1985: Gerd Binnig, Christoph Gerber, and Calvin Quate invent the atomic force microscope.

1985: Alec Jeffreys develops genetic fingerprinting.

1986: Laparascopic techniques allow surgery to be performed with less trauma to the body.

1992: John Daugman introduces the iris scanner.

1992: Researchers announce a link between folic acid deficiency and spinal cord birth defects.

1996: Protease inhibitor drugs hailed as newest tool in AIDs treatment.

1996: RU 486 is approved by the FDA for use in the United States.

Words to Know

A

adhesive: a substance that causes one object to stick to another.

alkaloid: any of various organic compounds containing at least one nitrogen atom. Alkaloids occur mainly in many plants and some fungi. Many alkaloids, such as nicotine, cocaine, and morphine, are known for both their addictive and medicinal qualities.

amino acids: organic compounds of nitrogen and hydrogen that combine with other elements to produce proteins.

analgesic: a substance that reduces or eliminates pain.

angina: severe chest pain associated with narrowing of arteries and reduction of blood flow to the heart.

antigen: a substance that, when introduced into the body, stimulates the production of an antibody. Antigens include toxins, bacteria, foreign blood cells, and the cells of transplanted organs.

antioxidant: a substance that prevents fatty acids from combining with oxygen.

antiseptic: a substance that stops the growth of organisms that cause infection.

aspirate: to remove liquids or gases using a suction device.

B

benign: harmless; without bad intent.

blood serum: the part of the blood that does not contain blood cells. Also called plasma.

C

cardiovascular: having to do with the heart and blood circulation systems.

carotene: an orange-red substance that is changed to vitamin A in the liver.

catalyst: a substance that speeds up chemical reactions without undergoing change itself.

cauterization: use of heat to seal wounded blood vessels and prevent uncontrolled bleeding.

chlorofluorocarbons (CFCs): very stable molecules made up of chlorine, fluorine and carbon, commonly used in aerosol products and for refrigeration.

cholesterol: an organic substance found in animal tissues and various foods. Cholesterol is normally synthesized by the liver and is important as a part of cell membranes. The cholesterol level in the bloodstream can influence certain conditions, such as the development of atherosclerotic plaque and coronary artery disease.

chromosome: a threadlike strand of DNA and associated proteins in the nucleus of animal and plant cells that carries the genes that transmit hereditary information.

coenzyme: any of a group of organic compounds that usually contain a vitamin or mineral. These compounds combine with proteins to form enzymes.

collagen: a protein that makes up connective tissues such as ligaments and tendons.

congenital: something present in the body from the time of birth.

contraception: birth control.

contrast agent: dye injected into the human blood stream to detect blockages in blood flow.

cornea: the transparent covering of the eye.

coronary: of or relating to the heart and the arteries and veins which are attached to it.

D

diffraction: a change in the direction of a group of waves, such as light waves, when they strike an object or pass through a small opening.

diffusion: the continual movement of molecules in air or water.

distillation: the process of separating alcohol from the grains and fruits it was fermented from and condensing the separated alcohol into pure liquid.

dressing: materials used to cover wounds.

E

embryo: an unborn animal in the initial stages of development; an unborn human, from implantation of the fertilized egg in the uterus through the eighth week of the pregnancy.

emulsify: the suspension of one liquid inside another in which the liquids do not mix together, such as oil in water.

endocrine glands: any of a group of glands that produce hormones.

enzyme: any of numerous proteins produced by living organisms that function as catalysts, or starters, for biochemical reactions.

F

fermentation: the process of transforming sugar into alcohol.

fetus: an unborn animal in the mid-to-later stages of development; in an unborn human, the fourth to ninth month of the mother's pregnancy.

G

glucose: a monosaccharide sugar occurring widely in most plant and animal tissue. Glucose is the main circulating sugar in the blood and the major energy source of the body.

glycogen: a polysaccharide that helps with carbohydrate storage in animals. Glycogen occurs primarily in the liver and in muscle tissue.

H

hemoglobin: the iron-containing protein in the blood's red cells which carries oxygen to the cells of the body.

hemorrhage: uncontrolled bleeding.

heredity: the physical characteristics passed by the genes from one organism to another.

hypothalamus: the part of the brain that lies below the thalamus, or lower portion. Its functions are to regulate bodily temperature, certain metabolic processes, and other involuntary body activities.

I

immunosuppressant: a substance that prevents the immune system from attacking transplanted organs.

inebriation: state of the body after consuming too much alcohol.

inert: chemically inactive; a material unable to react with other chemicals.

infertility: the inability to have children.

inflammation: a localized protective reaction of tissue to irritation, injury, or infection, characterized by pain, redness, swelling, and sometimes, loss of function.

invasive: involving entry into the living body.

ion: an atom or a group of atoms that has an electric charge by gaining or losing one or more electrons.

isotope: one of two or more atoms of the same chemical element but with different masses.

L

lacerations: cuts or openings in the skin caused by injury.

leukocyte: any of the white blood cells that fight disease in the body.

ligament: a band of tough, elastic tissue that binds bones together at a joint.

ligature: the tying off of blood vessels in order to prevent uncontrolled bleeding.

lipids: a group of organic compounds, including fats, oils, waxes, sterols, and triglycerides, that are insoluble in water but soluble in common organic solvents, are oily to the touch and, together with carbohydrates and proteins, make up the principal structural material of living cells.

lymphocyte: white blood cells produced by the lymphatic tissues of the body. Lymphocytes function in the development of immunity.

M

malignant: acting with the purpose of harming.

malocclusion: a term for teeth that are crooked or misaligned.

midwife: a medically trained person, though not a doctor, who specializes in assisting with childbirth.

miscarriage: a spontaneous (unplanned) abortion of an embryo or fetus.

N

neoplasm: any of a group of cells that grow more rapidly than normal.

neurology: the study of the nervous system.

neuron: any of the impulse-conducting cells that make up the brain, spinal column, and nerves. Also called nerve cells.

nucleic acids: group of acid substances found in the nucleus of all living cells.

O

obstetrics: the medical study of childbirth.

opiate: chemicals derived from opium, a product of the poppy plant. When injected, opium gives a feeling of relaxation and happiness and relieves feelings of pain. Opiates include heroin, morphine, and methadone.

osmosis: the movement of water across a membrane (barrier) when there is a different concentration of molecules on one side of the membrane than on the other.

ovum: the egg of the human female which originates in the ovaries.

oxidant: a chemical compound that combines with other compounds to produce oxides and water.

ozone: a form of oxygen molecule with three atoms of oxygen.

P

pathology: the study of diseases.

peptide: any of various natural or synthetic compounds containing two or more amino acids linked together.

pharmaceutical: having to do with the development and distribution of drugs for medical uses.

placenta: an organ which lines the uterus and holds a fetus and its fluids during the mother's pregnancy; also contains the blood supply through which nutrition and oxygen are passed to the fetus through the umbilical cord.

plasma: that part of the blood which does not contain the blood cells. Also called blood serum.

prognosis: a prediction of the probable course and outcome of a disease.

prosthesis: an artificial limb.

puberty: the stage of adolescence when a person undergoes bodily changes, such as the onset of menstruation and the growth of facial hair.

R

retina: a light-sensitive membrane lining the inner eyeball and connected by the optic nerve to the brain.

retrovirus: a virus that invades a healthy cell and copies its DNA (genetic information) to that cell.

S

soluble: capable of being dissolved.

sputum: mucus from the lungs.

sterility: inability to have children

steroid: any of a group of fat-soluble organic compounds, including the sterols and bile acids, and adrenal and sex hormones.

sublime: to pass directly from a solid to a vapor, skipping the liquid state.

sutures: surgical stitches to hold the edges of a wound together.

synthetic: substances produced by human attempts to blend or combine materials that do not naturally occur together.

systemic: acting throughout an entire system. Systemic medications affect the whole body, not just a small part.

T

tachycardia: a fast, irregular heartbeat.

T-cell: white blood cells that attack disease-causing organisms or other foreign bodies, such as transplanted organs, in the body.

therapeutic: something used for treatment of illness.

thrombolysis: process of dissolving blood clots.

toxin: an invading organism that will cause disease and damage the body.

toxoid: a disease-causing organism that is chemically treated to end its ability to cause disease. Treated toxoids help generate immunity.

tubal ligation: the tying of ovarian tubes in the female to prevent the release of ova (eggs) and provide permanent birth control.

U

ultrasound: frequencies above the range of human hearing; in medicine, the use of ultrasonic waves to create pictures of internal body structures and organs.

V

vas deferens: the tubes that connect the male testicles to the penis.

vasectomy: the cutting and tying of testicular tubes in the male to prevent sperm from causing a pregnancy.

ventricular fibrillation: irregular contractions of the heart.

volatility: ability of a liquid to change to a gas at room temperature.

Z

zygote: a fertilized ovum or egg.

Magnetic resonance imaging (MRI)

Magnetic resonance imaging (MRI) is a tool of medical diagnosis used to examine tissues and organs inside a patient's body. MRI assembles a detailed, readable image based on the response of atoms placed within a strong magnetic field.

MRI Detects Cancer

The MRI can detect small tumors (growths) that might be cancerous. Because cancer cells have a resonance frequency different from healthy cells, they are readily identifiable. MRI can outline areas of soft tissue too thin to be picked up by X-rays. It can also see into large organs. MRI is used primarily to diagnose disorders and injuries of the head and the spine as well as congenital heart disease, cardiovascular disorders, and pelvic problems, and MRI can also be useful for examining the chest, joints, and the circulatory system.

How MRI Works

The MRI scanner is composed of a large, tube-like magnet, radio transmitters, and receivers, and a computer. The patient lies inside the tube, completely surrounded by an intense magnetic field. Inside the patient's body, the nuclei of certain atoms will spin, wobbling at precise frequencies. Using the radio signals, the computer searches for the frequencies associated with specific types of atoms (such as cancer cells). Once the radio waves are turned off, the atoms emit pulses of absorbed energy. The computer reads these pulses and uses them to draw a three-dimensional image of the scanned area.

MRI scanners, which are particularly expensive, are generally found only in large medical research centers. A specially trained radiologist must be present to supervise the procedure.

NMR

MRI technology is based on an earlier research technique known as nuclear magnetic resonance (NMR), which helps scientists to analyze the interactions between matter and electromagnetic radiation. In 1973, a paper published in *Nature* first explained how to use NMR on human bodies. The technique later came to be known as MRI, and since 1981, when it came into extensive use, MRI has proven its tremendous diagnostic value.

The MRI technique is also radically different from **X-ray** technology, because MRI uses no ionizing radiation.

An MRI machine. MRI assembles a detailed, readable image based on the response of atoms placed within a strong magnetic field.

Magnifying glass

The magnifying glass is one of the most ancient optical (related to the eye) devices known to science. Thousands of years ago Egyptians used chips of crystal or obsidian (a type of shiny stone) to better view small objects. In Rome Emperor Nero (A.D. 37-68) was known to have peered through gemstones at actors on a distant stage. The first magnifier constructed for scientific purposes is believed to have been designed by the English philosopher Roger Bacon (circa 1220-1292) sometime during the thirteenth century.

The magnifying glass is one of the most ancient optical devices known to science.

Most magnifying glasses are double-convex lenses and are used to make objects appear larger. This is accomplished by placing the lens close to the object to be viewed. In this way the light rays are bent toward the center of the lens. When these bent rays reach the eye they make the object appear much larger than it actually is. However, if the object is far enough

A magnifying glass in use. Most magnifying glasses are double-convex lenses used to make objects appear larger.

away from the lens, the image will flip, appearing smaller and upside down. The distance at which this flip occurs is twice the focal length (the distance from the optical center of a lens to the point where the light rays converge) of the lens. The focal length of any lens is determined by the amount of curve on the lens' face. The magnified image is called a virtual image while the smaller, inverted image is called the real image.

Many people have used a magnifying glass and sunlight to ignite a piece of paper. When the lens is held at exactly two focal lengths from the paper, all of the light will be concentrated into a tiny point, generating enough heat to start a fire.

The magnifying glass was the forerunner of the **compound microscope** (in which a series of lenses are used to focus, magnify, and refocus an image), one of the basic tools used in medicine.

[*See also* **Microscope, compound**]

Mammography

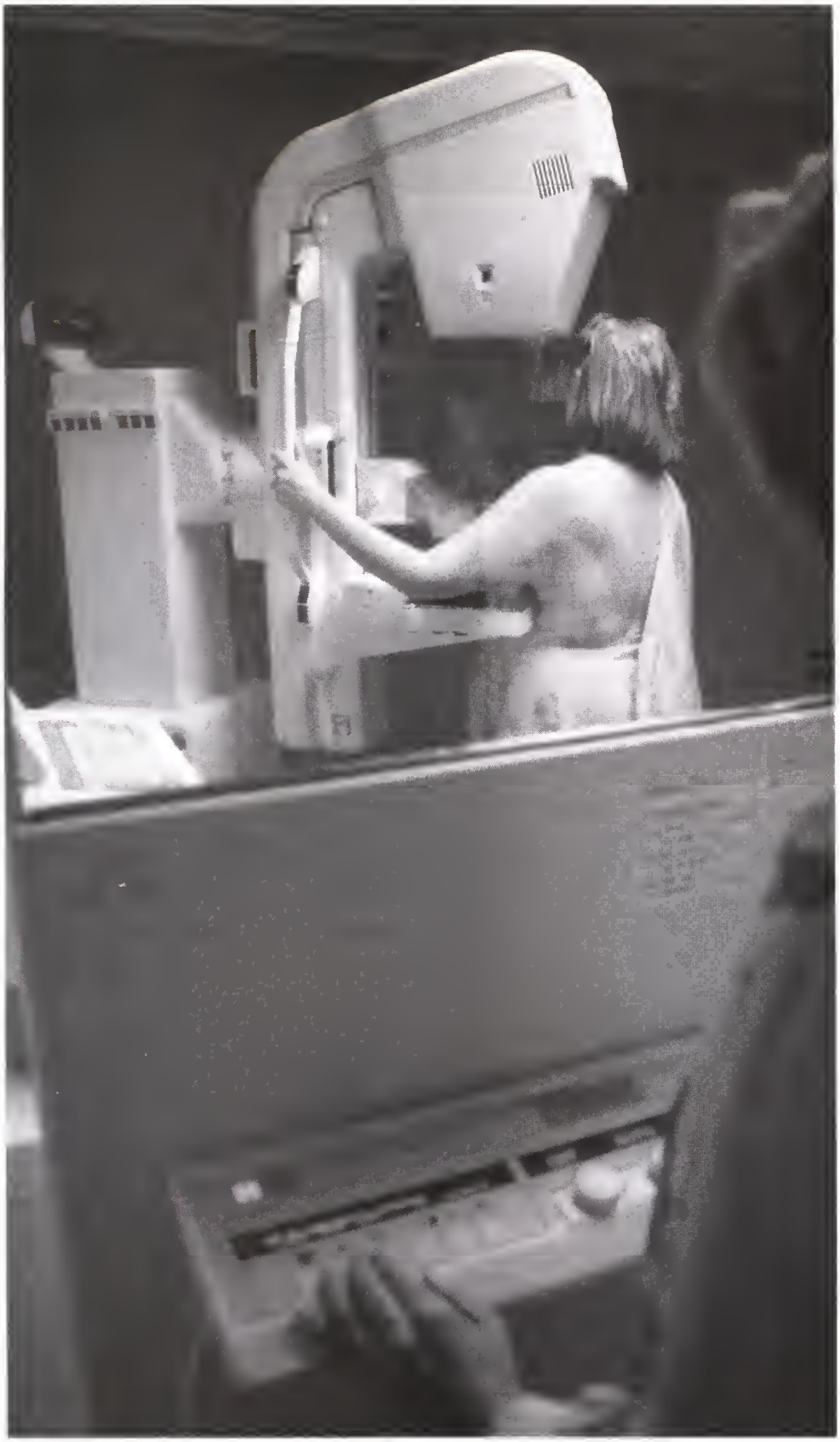
Breast cancer is one of the leading causes of death among women, but it can also affect men. Approximately one out of every nine women will develop breast cancer in their lifetime.

Breast cancer is one of the leading causes of death among women, but it can also affect men. Approximately one out of every nine women will develop breast cancer in their lifetime. Mammography is **X-ray** imaging of the breast to detect breast cancer. In many cases, mammography can detect tumors while they are still small and most easily treated.

Mammography is an important diagnostic tool. Studies show that women who are treated early for breast cancer have a five-year survival rate of 82 percent. Women whose cancers are not detected and treated early have a five-year survival rate of just 60 percent.

Early Mammography

When X-ray technology was first developed in the late nineteenth century, doctors began applying it to different medical problems. German surgeon Albert Salomon was the first researcher to use X-ray technology to detect breast cancer. Salomon used X-ray photography on breast tissue that had already been removed in order to see the differences between healthy and diseased tissue. When reviewing the resulting X-ray pictures, Salomon discovered that there were a number of different types of breast cancer. He published his findings in 1913, but never used the technique in his own practice.



A woman undergoes mammography screening. For women under forty, the procedure is recommended only for those at risk of developing the disease because of a family history of breast cancer or other high-risk factors.

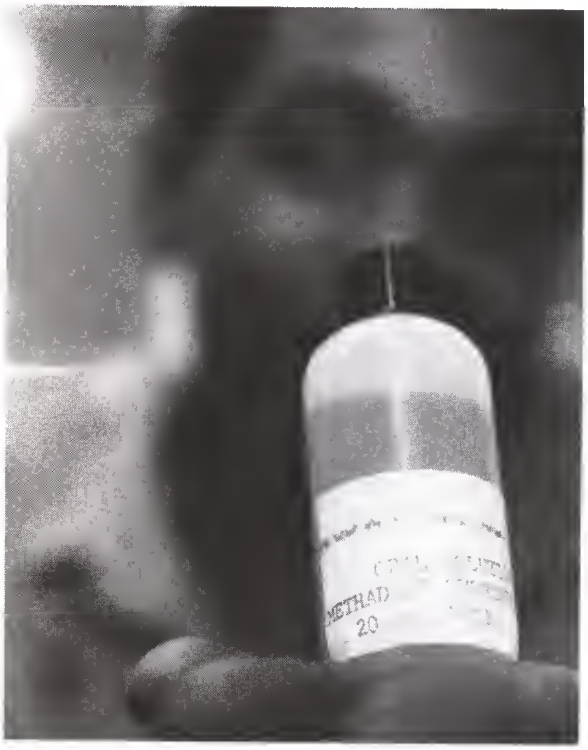
In the 1920s other researchers provided more detailed guidance on detecting cancerous tumors with X-rays. A German researcher named W. Vogel fully described how X-rays could detect differences in breast tissue. In fact, Vogel's guidelines are still used by doctors today. Stafford L. Warren, an American physician practicing in the 1930s, was the first doctor to use mammography to diagnose breast cancer prior to surgery.

Mammography Use and Controversy

In the mid 1950s, thanks to the Jacob Gershon-Cohen's use of mammography to screen healthy women for breast cancer, mammography became more popular among doctors. By the 1960s mammography was a widely used diagnostic tool. Some critics claimed that the X-ray procedure exposed women to dangerous levels of radiation, but much of this criticism stopped with the development of more sensitive film that significantly reduced the amount of radiation used in the procedure.

The National Cancer Institute conducted a four-year study (1973-1977) of some 270,000 women throughout the United States. It found that large numbers of women who had very small, benign (non-cancerous) growths had undergone breast surgery, many after mammography screening. Some researchers felt many of these surgeries were unnecessary.

As a result of the study, the Institute issued guidelines regarding which groups of women would benefit from regularly scheduled mammograms. For women under forty, the procedure was recommended only for those at risk of developing the disease because of a family history of breast cancer or other high-risk factors.



A oral solution of methadone. The drug is often mixed with fruit juice to give it a better taste. This helps make it more appealing to patients.

Methadone

Methadone is used as a substitute for heroin and **morphine** to treat opiate addiction. To understand what methadone does, it is first necessary to understand how opiates act on the body.

Heroin and morphine are opiates. They are both derived from **opium**, a product of the poppy plant. These drugs interact with the opiate receptors in the brain. The reaction of opiates in the brain causes sedation, analgesia (an inability to feel pain), and a euphoric (very happy),

"high" sensation. It is because of these effects that opiates are considered addictive and are frequently abused.

Methadone is similar to morphine and opium in that it produces the same effects. The effects of methadone on the body last longer, however, than with opiates. It is the long-lasting effect of morphine that has made it a good treatment for opiate addiction.

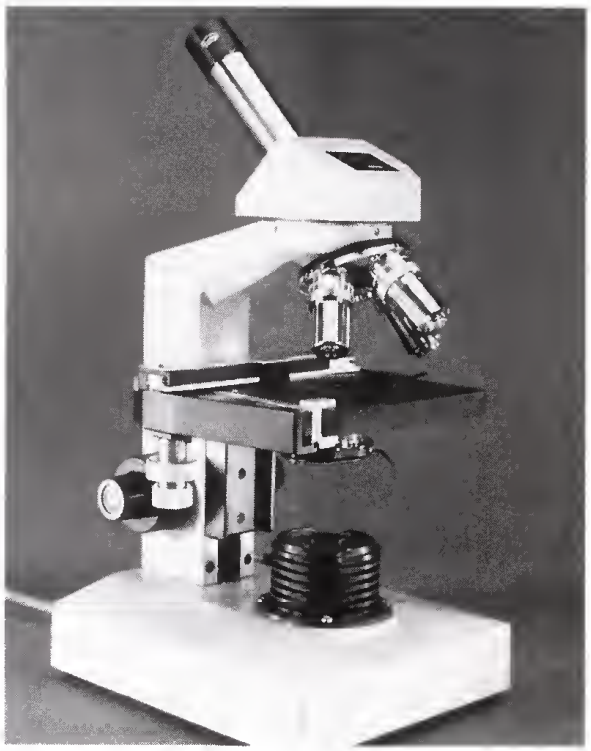
In addition to having longer-lasting effects, methadone's withdrawal symptoms are much less severe than with opiates. Methadone also acts as a blocker in the brain so that addicts are less likely to go back to heroin because it will not give them the usual high.

Once a person is addicted to methadone, the standard treatment is to slowly wean them off the drug. This deliberate withdrawal is made easier because of methadone's less-severe withdrawal symptoms.

Microscope, compound

Compound microscopes are found in almost all medical laboratories and in many industrial research centers.

Microscopes have been in use in various forms for more than 3,000 years. The first microscopes were extremely simple magnifiers made of globes of water-filled glass or chips of transparent crystal. Ancient Romans were known to use solid, bead-like glass magnifiers. Emperor Nero (A.D. 37-68) often used a bit of cut emerald to help his poor vision.



The first lenses that were used in primitive **eyeglasses** were manufactured in Europe and China in the late thirteenth century. By this time lenscrafters realized that most clear glass or crystal could be ground into a certain shape (generally with the edges thinner than the center) to produce a magnifying effect. All of these single-lens magnifiers are called simple microscopes.

van Leeuwenhoek's Lenses

Until the turn of the seventeenth century, most simple microscopes could provide a magnification of 10 power (magnifying a specimen to ten times its diameter). About this time Dutch draper and amateur optician **Antoni van**

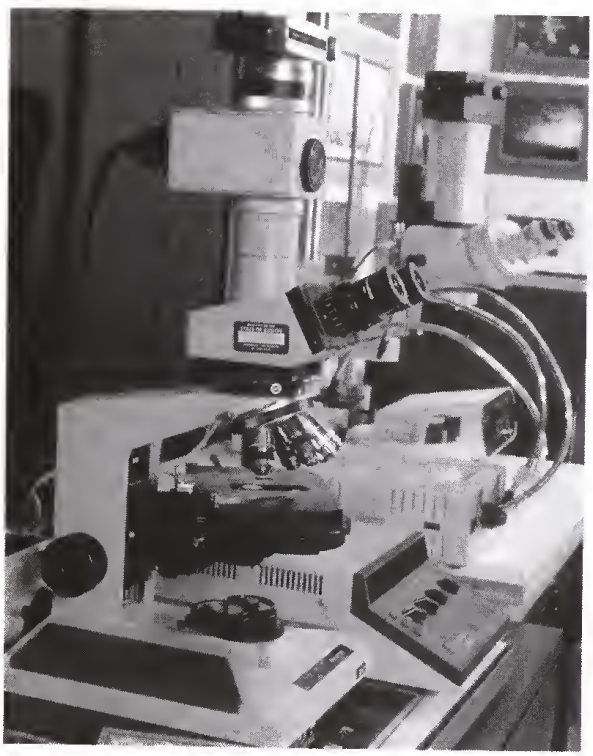
Leeuwenhoek (1632-1723) began constructing magnifying lenses of his own. Though still relying upon single lenses, Leeuwenhoek's unparalleled grinding skill produced microscopes of very high power, with magnifications ranging to 500 power.

In order to achieve such results, Leeuwenhoek manufactured extremely small lenses, some as tiny as the head of a pin. Because of the very short focal length of these lenses (focal length is the distance of focus from the object to the lens), the microscope had to be held only a fraction of an inch away from both the observed specimen and the observer's eye. Through his minute lenses Leeuwenhoek observed tiny "animalcules" (what we now know as bacteria and protozoa) for the first time. His findings earned him international acclaim, and the simple microscopes he designed are still among the best-crafted.

Multiple Lenses Improve Magnification

The limitations of the single-lens magnifier were apparent to scientists. They labored to develop a practical system to increase microscope magnification. The next breakthrough in microscopy was the invention of the compound microscope. While the origin of this device and the identity of its inventor are the subject of some debate, credit for the invention of the compound microscope has generally been given to Dutch optician Zacharias Janssen (1580-circa 1638). Around 1590 Janssen reportedly stumbled upon an idea for a multiple-lens microscope design, which he then constructed. Though he affirmed its ability, no record exists of Janssen actually using his invention. It is now believed that Janssen's son fabricated the story.

A photomicroscope, one of the many modern variations of the simple microscope.



Meanwhile, Dutch scientist Cornelius Drebbel claimed that he had constructed the first compound microscope in 1619. The astronomer Galileo (1564-1642) also reported using a two-lens microscope to examine and describe the eye of an insect.

Regardless of its inventor the design of the original compound microscope is very similar to those used today. Two or more lenses are housed in a long tube. Individually, none of the lenses are particularly powerful. The image produced by the first lens is further magnified by the second (and the third and fourth, in a multiple-lens system), ultimately producing a greatly enlarged

image. In addition, multiple lenses allow for a much longer focal length. This permits both the specimen and the viewing eye to be placed at a greater distance from the lenses.

The first scientist to further improve the compound design was the Englishman Robert Hooke. Hooke was the first researcher to use a microscope to observe the structure of plants. He found them to consist of tiny walled "chambers" that he called cells.

Zeiss and Abbe

After Hooke, little advancement occurred in microscopy until the collaborative work of German manufacturer of optical glass **Carl Zeiss** (1816-1888) and German physicist **Ernst Abbe** (1840-1905) in the mid-1800s. Abbe, generally recognized as the first optical engineer, took over design duties at the Zeiss Optical Works in 1876. The scientific instruments that resulted from Zeiss and Abbe's collaboration set new standards for optical equipment. Among their inventions were lenses that corrected blurring and color aberrations (defects or imperfections).

Electron Microscope Magnifies Atoms

By the twentieth century the essential design and shape of the compound microscope had evolved into the same form we know today. Microscopes used in schools and small laboratories can achieve magnification of up to 400 power. More advanced microscopes used in research laboratories can magnify a specimen to almost 1000 power. These research microscopes often have binocular eyepieces, which rely upon a series of prisms to split the image so that it may be viewed with both eyes. Even trinocular microscopes have been designed, which create a third image for a camera to view.

The practical limit for any compound microscope is 2,500 power. In the twentieth century this limited magnification capability frustrated scientists who were anxious to view the world on submicroscopic and subatomic levels. In 1931 German scientist Ernst Ruska (1906-1988) constructed the electron microscope, thus permitting such investigations.

Designed much like a compound microscope, the electron microscope uses a beam of electrons focused through magnetic lenses. Since electrons possess much smaller wavelengths than does visible light, the electron microscope can provide much higher magnification than light-based instruments. Through electron microscopes scientists first viewed strands of DNA. Since Ruska's invention, instruments such as the scanning tunneling microscope and the field ion microscope have been devel-

oped. These devices are capable of observing the activities and structures of individual atoms.

Morphine

Morphine is the most effective naturally-occurring compound used to relieve pain. It also induces sleep and produces euphoria (a feeling of well-being). Morphine is an opiate (derived from **opium**) and is named for Morpheus, the Greek god of dreams.

Morphine's Advantages and Disadvantages

Morphine is a narcotic (it dulls the senses). It acts on the central nervous system to allow a person to tolerate more pain than would otherwise be possible. Morphine produces a calming effect which protects the body in traumatic shock. Its greatest disadvantage is its addictiveness.

In 1898 the Bayer corporation synthesized **methadone** from morphine and marketed it as an antidote to morphine addiction. Methadone is a synthetic (artificial) drug that is less addictive than morphine. Today, methadone is often used in place of morphine as a pain killer. It is also used for the treatment of morphine and heroin addictions.

Niacin

Niacin, or nicotinic acid, is a member of the water-soluble **vitamin B** family. For the most part, niacin functions as part of two important coenzymes. Both **enzymes** play vital roles in a number of metabolic pathways, in particular, those pathways concerned with cellular respiration (the process by which tissue cells "burn" carbohydrates and proteins in order to release energy) and, to a lesser extent, those pathways involved in the synthesis (blending) of fatty acids and **steroids.**

Pellagra

A deficiency of niacin causes pellagra, a serious disease which has plagued mankind for centuries. In most cases pellagra strikes people whose diet consists mainly of corn and cornmeal. Until fairly recently, pellagra was a major health problem in the United States. In the 1920s the disease killed thousands of people in poor rural areas. At that time, pellagra patients filled both hospitals and, because mental confusion was one of its symptoms, mental institutions as well.

Although no one knew the exact cause of the disease, by the beginning of the twentieth century more and more researchers began to suspect that a dietary deficiency was responsible. The search for an "anti-pellagra factor" intensified in both Europe and the United States. In 1912, Casimir Funk (1884-1967), the Polish-born biochemist who coined the term **vitamin**, managed to isolate the right factor—nicotinic acid—from rice polishings. Unfortunately, at the time Funk was actually hunting for a substance that would cure beriberi, another serious deficiency disorder. When he found that nicotinic acid had only a minimal effect on beriberi, Funk

pushed the compound aside. In the years that followed, the compound was largely ignored.

Niacin and Vitamins

In the 1930s, a number of researchers—among them Hans Euler-Chelpin, Otto Warburg, and Arthur Harden—began reporting that nicotinic acid appeared to be part of quite a few vital coenzymes. Perhaps, the researchers suggested, the compound was a lot more important than was originally supposed.

Niacin wasn't fully established as a vitamin until 1937. It was then that a team of researchers headed by American biochemist named Conrad Arnold Elvehjem (1901-1962) administered 30 miligrams of nicotinic acid to a dog suffering from blacktongue (the canine equivalent of pellagra). The dog improved immediately and, with further doses, was soon completely cured.

Other biochemical researchers quickly confirmed that niacin was the anti-pellagra vitamin for humans. They also confirmed that adding foods high in niacin to the diet, such as meat, green vegetables, yeast, and most grains, dramatically cured the disease. Moreover, since tryptophan is converted by the body into niacin, adding milk and other tryptophan-rich foods to the diet worked equally well.

Very quickly, pellagra cases began declining. In 1941 breads and cereals routinely began to be fortified with the vitamin. It was then that pellagra ceased to be a problem in the United States. The disease does crop up occasionally in other parts of the world, usually where poor diet is a problem.

Nitrous oxide

Nitrous oxide was first identified by Joseph Priestley in 1772. Years later in the late 1790s, British chemist **Humphry Davy** (1778-1829) began experimenting with the effects of inhaling nitrous oxide. He noted its exhilarating effects, especially the way it made him want to laugh. This fact helped give the gas its popular nickname, "laughing gas." Davy published his findings in 1800, remarking that "As nitrous oxide ... appears capable of destroying pain, it may probably be used with advantage during surgical operations."

Nitrous Oxide and Dentistry

Little attention was paid to Davy's observations or to those of Henry Hill Hickman (1800-1830). Hickman was a general practitioner from

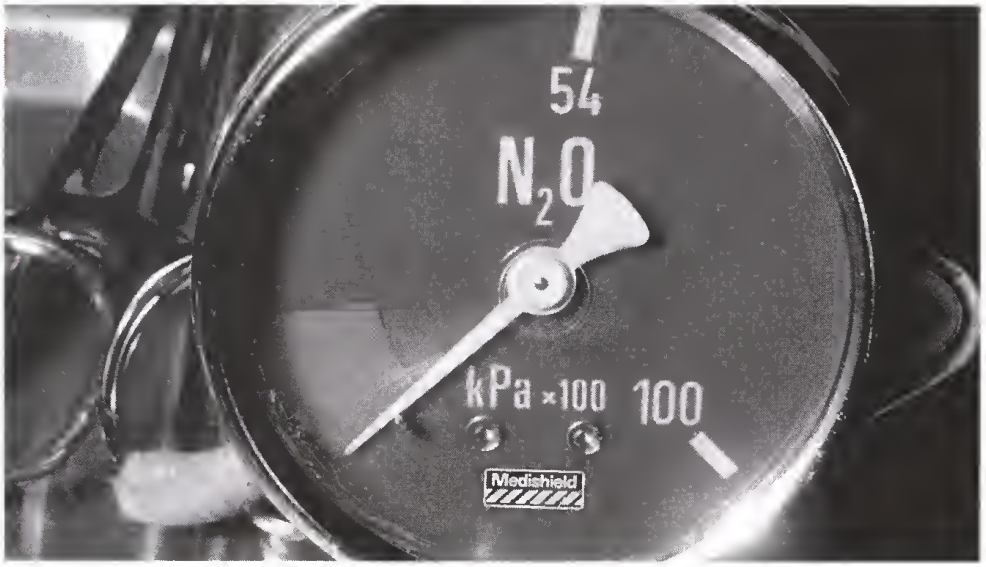
Shropshire, England, who in 1824 explored methods of painless surgery on animals using both carbon dioxide and nitrous oxide gas. Davy repeatedly demonstrated the gas's exhilarating effects to gatherings of his friends, and inhalation parties became quite popular. Use spread to the United States as traveling lecturers spread knowledge about the new chemistry to the general public. These lectures usually including a demonstration of the effects of nitrous oxide inhalation on audience volunteers.

A New Anesthetic

One of these public lectures was given in Hartford, Connecticut, in 1844 by Gardner Quincy Colton (1814-1898). It was attended by local dentist Dr. Horace Wells (1815-1848). Wells observed that a volunteer, Samuel Cooley, obviously hurt himself while under the influence of nitrous oxide but didn't notice the pain. Wells immediately thought of using the gas to banish pain during tooth extraction. The next day he took some of Colton's gas while a fellow dentist removed one of Wells's teeth. As he had expected, Wells felt no pain.

After confirming the **anesthetic** effect of nitrous oxide on other patients, Wells arranged through his former dental partner, William T. G. Morton (1819-1868), to demonstrate his discovery to a group of Morton's Harvard Medical School classmates in January 1845. Unfortunately, the nitrous oxide was applied incorrectly, and the patient yelped with pain when his tooth was pulled, embarrassing Wells before the group.

After Morton used **ether** successfully as an anesthetic in 1846, Wells pressed his claims for primacy as the discoverer of anesthesia. Frustrated



Nitrous oxide in use. Chemist Humphry Davy noted its exhilarating effects, especially the way it made him want to laugh. This helped give nitrous oxide its popular nickname, "laughing gas."

in these attempts, Wells began to abuse **chloroform** (a clear, colorless, heavy liquid used in refrigerants, propellants, resins, and as an anesthetic). He committed suicide in 1848 being arrested for throwing acid at two women in New York City.

A Practical Anesthesia

Nitrous oxide was finally made a practical anesthetic by Colton in 1863. Edmund Andrews (1824-1904), a Chicago surgeon, began to use nitrous oxide in combination with oxygen in 1868. As this method gained popularity, nitrous oxide became a staple in surgical as well as dental practice.

Novocain

Novocain is a local anesthetic (painkiller) used by doctors and dentists. It was developed as a substitute for **cocaine** in 1905 by German researcher Alfred Einhorn. The trade name Novocain comes from the Latin word "novus," meaning "new," plus "cocaine." Other synthetic substitutes for cocaine include tropocaine, aucaine, monocaine, and lignocaine.

Cocaine as a Local Anesthetic

Cocaine was widely used as a local anesthetic after Carl Koller (1857-1944) demonstrated the drug's effectiveness in 1884. By the end of the 1800s, however, the addictive properties of cocaine were recognized. Doctors knew they needed a substitute for cocaine's anesthetic effect. They began to carefully study the structure of cocaine for possible alternatives. Many of the first synthetic cocaine products were too irritating to use. The first successful cocaine substitute was stovaine, invented by Ernest Fourneau (1872-1949) in 1904.

Soon after Einhorn's discovery of novocain, Guido Fisher popularized the drug's use in the United States. Injected by a needle, novocain immediately became popular as a local anesthetic for both medical and dental purposes.

Olestra

In 1996 the Food and Drug Administration (FDA) approved a new synthetic fat called olestra. Olestra is a sucrose polymer that has absolutely no food value. In fact, there have been problems associated with Olestra that make its use and safety highly questionable under certain circumstances.

Olestra Complications

Olestra is known to cause diarrhea and cramping. It also robs the body of valuable nutrients called carotenoids. Carotenoids are carotenes (hydrocarbons) that occur in yellow vegetables like carrots, squash, and corn. Carotenes are stored in the liver and converted to **vitamin A** by the liver. The loss of these nutrients can cause an increase incidence of cancer, heart disease, and blindness.

Big Hopes

Originally, olestra was created to provide consumers with a fat-free food substitute that did not change the taste or texture of the food it appeared in. For over twenty-five years, corporate giant Proctor and Gamble had worked on creating such an ingredient. In fact, the company was so sure its product would revolutionize food processing that it created an "Olestra Division" to create and market the additive. Unfortunately for Proctor & Gamble, the FDA approval process dragged on for years, to the extent that other companies were able to come up with their own olestra-like substances

Problems Arise

After years of conducting internal and external tests, the FDA gave

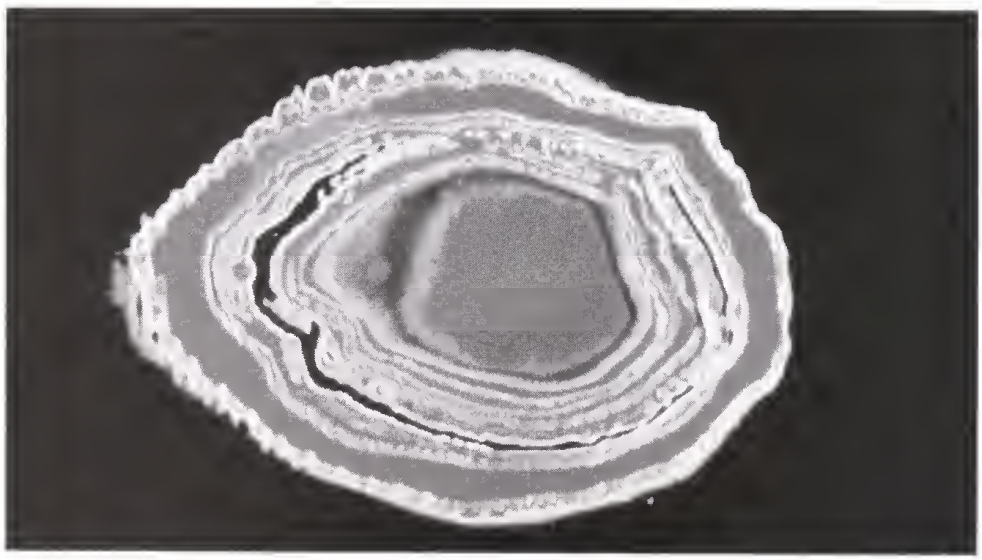
conditional approval for olestra use in snacks like potato chips and crackers. According to FDA guidelines, foods containing olestra must carry a warning label common to all synthetic food additives. This warning notes possible side effects and complications from use.

The warning was not enough for some groups, however. The Center For Science in the Public Interest, for example, feels that olestra has not been tested enough, and could cause dangerous, long-term side effects like cancer and heart disease. Despite the controversy, products containing olestra have been test marketed in limited areas with generally positive results. For the time being at least, Proctor & Gamble plans to create more snack foods containing the fake fat.

Open-heart surgery

Opening the chest to operate directly on an exposed heart is major surgery. For many years the procedure was considered impossible because performing the operation would cause the heart to stop beating. A few pioneers, however, did perform emergency surgery directly on the open heart. One of the first was African-American surgeon Daniel Hale Williams (1858-1931). Williams opened the chest of a stabbing victim and sewed up the pericardium (the sac surrounding the heart) in 1893. The success of the surgery made headlines in the *Chicago Daily Inter-Ocean*.

Ludwig Rehn experimented with suturing wounds of the heart in 1896, but more lengthy and complicated heart operations were out of the

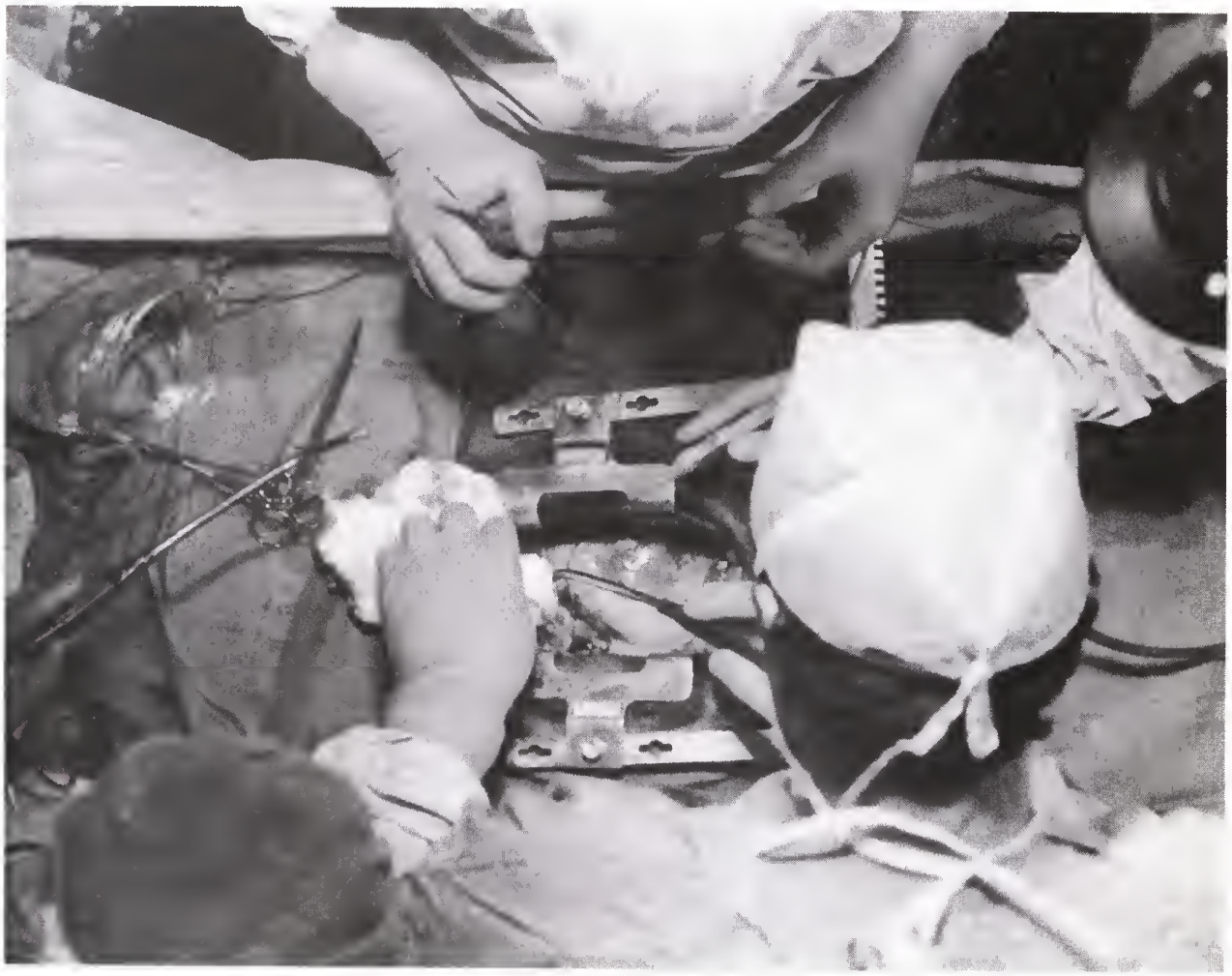


A coronary artery blocked by plaque.

question. If the heart was being repaired, there had to be a way to keep the blood oxygenated and circulating. Without the an outside device, the patient would surely die.

Gibbon's Heart-lung Machine

An American surgeon named John H. Gibbon, Jr. (1903-1974) devoted himself to solving this problem in the 1930s. Assisted by his wife Mary, Gibbon developed a workable pump-oxygenator in 1931. This **heart-lung machine** shunted (switched) blood from the veins through a catheter (a slender tube) to a machine. The machine supplied the blood with oxygen and then pumped the blood back into the arteries. On May 5, 1953, Gibbon ushered in the era of open-heart surgery by using his heart-lung machine on a patient suffering from heart failure. In the procedure, Gibbon connected patient Cecilia Bavolekto to the machine and closed an opening between her heart's atria (upper chambers of the heart).



Doctors perform open-heart surgery. Today, the procedure is used for both the replacement of defective heart parts and repair of cardiac malfunctions.

The methods and technical details of open cardiac surgery were refined throughout the 1950s by a number of surgeons and engineers. Most notable of these were Owen Wangenstein at the University of Minnesota and John W. Kirklin at Minnesota's Mayo Clinic. By 1960 open-heart surgery had become fairly standard. Open heart procedures began to be used for replacement of defective heart parts and not just for repair of cardiac (heart-related) malfunctions. Surgeons Albert Starr and M. L. Edwards of Portland, Oregon, designed a ball-and-cage artificial heart valve and successfully implanted it in a 52-year-old patient in 1961.

Coronary Artery Surgery

The heart gets its blood supply from the coronary arteries that branch off from the aorta. These arteries tend to become narrow from accumulations of plaque (blockage), which also promotes clot formation. When the coronary arteries become blocked the result is severe chest pain, or angina, and in some cases a heart attack.

Rene G. Favalaro introduced coronary artery bypass surgery in 1967. Favalaro and his surgical team at the Cleveland Clinic devised a technique that included creating an alternate blood pathway. They did this by grafting (transplanting) a vein from the patient's leg to bypass a blocked portion of a coronary artery. This bypass surgery was made possible by the use of microsurgical techniques and Gibbon's heart-lung machine.

Favalaro also used **coronary arteriography** (which produces a direct image of the heart prior to open-heart surgery). Within three years of Favalaro's pioneering 1967 operation, coronary bypass surgery gained wide acceptance. Its use in cases of mildly clogged arteries dropped off in the late 1970s with the advent of **balloon angioplasty**. Perhaps the most dramatic development in open-heart surgery was the heart transplant. This procedure was first successfully performed in Cape Town, South Africa, by **Dr. Christiaan Barnard** in 1967.

[*See also* **Artificial heart; Angioplasty, balloon**]

An ophthalmoscope enables a physician to examine the interior of the eye to detect abnormalities or signs of disease on the retina and lens of the eye.

Ophthalmoscope

An ophthalmoscope enables a physician to examine the interior of the eye to detect abnormalities or signs of disease on the retina and lens of the eye. It does this by directing a tiny beam of light through the pupil. The pupil is the black "window" of the eye.

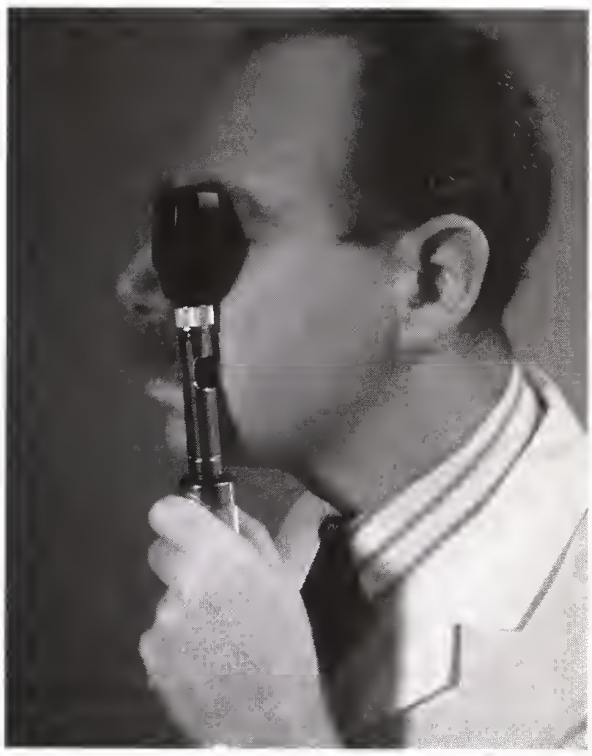
Babbage and Helmholtz

The first ophthalmoscope was invented in 1847 by Charles Babbage (1792-1871), an English mathematician. Babbage gave the device to a physician for testing, but it was laid aside and forgotten. Four years later, German physician and physiologist Hermann von Helmholtz (1821-1894) developed his own version of the ophthalmoscope. Helmholtz was unaware of Babbage's instrument. Because he had better luck making his device known, Helmholtz is often credited as the sole inventor.

Helmholtz's instrument operated by using a mirror to shine a beam of light into the eye. The observer would look through a tiny aperture (opening) in the mirror. Helmholtz found that looking through the lens into the back of the eye only produced a red reflection. By attaching a condenser lens he obtained a clearer inverted image, which was then magnified five times. He called this combination of a mirror and condenser lens an indirect ophthalmoscope. It was used regularly for eye examinations until 1920.

Helmholtz also invented the ophthalmometer, which was used to measure the curvature of the eye. The eye's curvature determines whether the focal point of an object's image will be on the lens of the eye, or in front or behind the lens. If the focal point isn't on the lens, the person will be near- or far-sighted. In addition, Helmholtz studied color blindness and the speed of nervous impulses. He also wrote the classic *Handbook of Physiological Optics*.

Swedish ophthalmologist Allvar Gullstrand (1862–1930), who also studied physiological optics, developed another version of the ophthalmoscope. He also invented a slit lamp, used with a microscope, that enabled a physician to locate foreign bodies in the eye.



A modern ophthalmoscope in use.

The Modern Opthalmoscope

The modern ophthalmoscope is a handheld instrument. It contains a small battery-powered lamp that directs the beam of light by way of a mirrored prism. The observer looks through a tiny hole in the prism. The instrument magnifies the image and can be focused by a series of revolving lenses. The lens needed to focus the image gives the doctor an approximation of the glasses lens prescription needed to correct the patient's vision.

A new type of ophthalmoscope that can project a laser beam is used in eye surgery to correct a detached retina. Another, larger type of ophthalmoscope, called the binocular ophthalmoscope, is used in clinical research. It provides an image of the eye that is magnified fifteen times.

Opioid receptor

Opium has long been a drug of interest to scientists. It is one of the most effective of all pain killers. Opium has the serious disadvantage, however, of producing addiction in long-term users. Research on the mechanism by which opium works in the central nervous system has a double appeal. It provides information on the nature of pain and on drug addiction.

In 1973 an important breakthrough in this research occurred. Solomon Snyder and Candace Pert at Johns Hopkins School of Medicine in Baltimore, Maryland, discovered receptors on brain cells to which opium will bind. Receptors are molecular groups within the cells that have a special affinity for toxins. These receptors have come to be called opioid receptors. The term opioid is used for any type of chemical that behaves in a manner similar to that of opium.

Snyder and Pert found two locations in the central nervous system where opioid receptors are most common. One is in the spinal column. It is here that pain is first detected. The second in the medial thalamus of the brain, where chronic pain is often concentrated. Solomon and Pert hypothesized that opium locks into opioid receptors on a cell. It then slows the rate at which that cell can transmit a "pain" message. These two actions may also be responsible for the sense of euphoria (bliss, happiness) that accompanies opium use.

In later research, the natural function of opioid receptors was discovered. John Hughes and Hans Kosterlitz at the University of Aberdeen (Scotland) found the chemicals that occur naturally in the human body that also bind to opioid receptors. These **enkephalins** are an important part of the body's natural pain-fighting mechanism.

[*See also* **Endorphin and enkephalin**]

Opium

Opium is a drug that is derived from the poppy plant. Its pain-relieving qualities have been known since ancient times. Opium was used by pre-

historic inhabitants of Switzerland, by Egyptians by about 1590 B.C., and by ancient Greek physicians around 400 B.C.. Opium was introduced to India and China around 600 B.C. by Arabian traders.

A Popular Drug

From the 1600s through the 1800s opium was one of the principal drugs in Western medicine. It was particularly promoted by the English physician Thomas Sydenham (1624-1689) to relieve pain, induce sleep, and treat strangulated bowel obstruction. Sydenham developed laudanum, a preparation of opium dissolved in sherry and flavored with saffron.

Opium was an ingredient of many of the popular **patent medicines.** While some of these products provided good medical treatment, many more were nothing more than opium- or alcohol-based solutions that numbed the body. Opium was also widely prescribed to consumptives (people suffering from tuberculosis) to relieve coughing and promote a sense of well-being. Opium use became widespread among artists and writers involved in the Romantic movement of the nineteenth century. In the days before **ether** was used as an anesthesia, opium was used to deaden the pain during surgery. Massive doses were usually the norm.

Opium Derivatives

Morphine, the main active ingredient in opium, was discovered in 1805 by German chemist Friedrich Sertürner (1783-1841). **Codeine,** another pain-killer derived from opium, was discovered a few years later by French chemist Pierre-Jean Robiquet (1780-1840). After the hypodermic **syringe** was invented in 1853, Alexander Wood (1817-1884) of Edinburgh, Scotland, developed a method of injecting morphine to relieve neuralgia (a severe sharp pain along the course of a nerve).

Morphine injection for relief of pain was enthusiastically embraced by the medical community. Doctors even taught their patients how to inject themselves. Morphine injection greatly increased the amounts of the drug that users were taking as compared with laudanum.

Gradually, the addictive properties of opium and morphine were recognized. Regular use resulted in dependency, and stopping use caused uncomfortable withdrawal symptoms. The recognition of these addictive effects and the discovery of ether as an anesthetic greatly reduced the use of opium. Despite the addictive qualities of morphine, it continues to be used. When prescribed properly and carefully it remains a very important and effective pain reliever. Ironically, the search for a morphine substitute that would kill pain but be nonaddictive resulted in the discovery of heroin.

[*See also* **Anesthesia**]

Orthodontics

Orthodontics is the dental specialty which deals with the positioning and relationship among the teeth within the jaw. The orthodontic goal is to move the teeth into the best position, not only for appearance, but more importantly for proper chewing, swallowing, breathing and speech. Orthodontists use a variety of "appliances" as the metal bands and wires are called, and techniques to move the teeth into proper position.

Getting Teeth Straight

Teeth-straightening and extraction have been practiced since ancient times to improve the alignment of the remaining teeth. Orthodontics was a minor part of general dentistry until the nineteenth century. The focus of ancient and medieval dentistry was on extracting decayed teeth and discovering the causes and prevention of decay. The first detailed analysis of orthodontic technique was given in *The Surgeon Dentist*, published in 1728 by Frenchman Pierre Fauchard (1690-1761). The volume devoted an entire chapter to tooth irregularities and ways to correct them. Another French dentist, Claude Mouton, also wrote on the irregularities of tooth position shortly after Fauchard's work. In England in 1771, John Hunter provided scientific names for the types of teeth and gained experience in transplanting and replanting teeth.

A brace mold. Orthodontists use a variety of appliances and techniques to move the teeth into proper position.

Orthodontics became a separate science in 1841 with the coining of the term orthodontia by Lafoulon. Again, a new book stirred the interest of the dental profession. This time it was J. M. Alexis Schange's volume on malocclusion (the abnormal fitting of the teeth in the upper and lower jaws). In 1858 Norman W. Kingsley, a gifted dentist and writer, made his mark on orthodontics with his *Treatise on Oral Deformities*. Another landmark work was J. N. Farrar's two volume set, *A Treatise on the Irregularities of the Teeth and Their Corrections*, which was profusely illustrated. Farrar was very good at designing appliances. It was he who suggested the use of mild force at intervals to move teeth.

Angle's Designs and Devices

Another influential figure in orthodontics was Edward H. Angle (1855-1930). Angle

devised the first simple and logical classification system for malocclusions. This system is still used as the basis for orthodontic diagnosis. He divided malocclusions into three types: Class I, where teeth are lined up correctly from top to bottom, but are spaced too far apart, or are crowded together, or crooked; Class II, where the upper teeth stick out too far beyond the lower ones (usually called an "overbite"); and Class III, where the lower teeth are too far in front of the upper ones (usually called an "underbite").

Angle contributed significantly to the design of orthodontic appliances and developed many simplifications. He founded the first school and college of orthodontia and organized the American Society of Orthodontia in 1901. In 1907 he also founded the first orthodontic journal. His highly-praised reference book, *Malocclusion of the Teeth,* went through seven editions.

In addition to Angle's work in basic orthodontic developments, Eugene Solomon Talbot (1847-1924) began the use of **X-rays** for orthodontic diagnosis. The use of rubber elastic bands to move teeth was pioneered by Calvin S. Case and H. A. Baker.

Materials and Techniques

Today, orthodontics has become a popular procedure to improve a person's smile, even if there is no functional problem with the teeth. The braces and wires used to move the teeth used to be uniformly made of metal, and were not very popular with the young people who had to wear them for up to several years. In the last 15 years, though, the metal bands have been replaced with small brackets that are bonded onto the front teeth, greatly reducing the "metal mouth" look. Metal bands are still used on the back teeth, which are harder to move. The wires guide the teeth into the proper position.

Thanks to improvements in materials and technique, braces can also be made of clear or tooth-colored ceramic materials, or applied to the inside of the teeth so they don't show as much. The wires can be made of new metal alloys (combinations of metals) that hold their shape better and reduce the time the patient has to wear braces. Other appliances include elastics and headgear to move the jaw into a new position, and retainers, which are used to keep the teeth in place after the braces are removed. Patients can even make a fashion statement with their braces by having some parts in different colors. The latest development is magnetic braces, where magnets are attached along the wires. These magnets can replace more visible and bulky items like headgear.

Oxygen tent

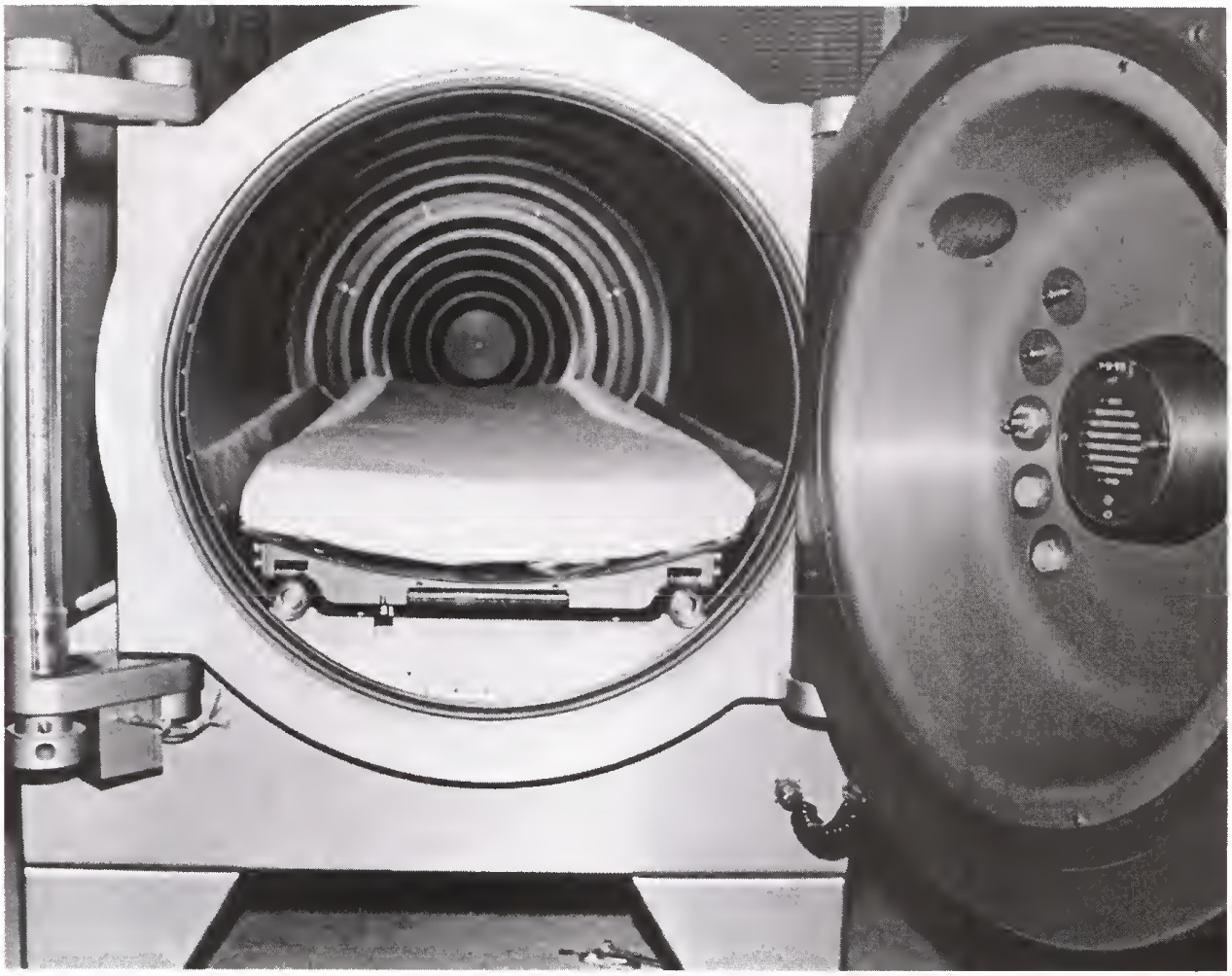
A mother visits her baby as it rests in a modern oxygen tent.

Oxygen tent

Around the year 1900, French physician Charles Michel (1850-1935) first realized the importance of oxygen to aid the recovery process from respiratory diseases. Oxygen helped the patients breathe easier and made them more alert by providing pure oxygen to the lung tissues and from there, into the blood. Michel used a small collapsible container around the patient's head, but the oxygen tent, as it was soon called, was soon expanded around a patient's entire bed. Oxygen tents then began to appear in hospitals in Europe and North America.

Tent Use and Design

Oxygen tents are most often used when a patient suffers from respiratory problems. Carbon monoxide poisoning or a disease like pneumonia can be helped with the oxygen tent. The tents are also used following



This hyperbaric oxygen chamber—an advanced offshoot of the oxygen tent—is used to prevent diver "bends" and gangrene.

an event in which the patient's body has been deprived of oxygen. The gas inside the tent has a higher percentage of oxygen than normally found in air. When the patient is in the tent and breathes, he or she is taking in more oxygen per breath.

The tent is usually a dome-shaped hood over a hospital bed. The tent seals out the regular atmosphere so that the patient can breathe only the oxygen-rich air that is forced in at the top of the tent. The tent is also equipped with a pump to keep the air circulating. The amount of moisture (humidity) in the tent is also controlled so that the lungs do not dry out. The carbon dioxide exhaled by the patient is continually monitored and removed.

Pacemaker

The rhythmic, regular beating of the heart is controlled by a natural cardiac pacemaker called the sinoatrial node. This small patch of cells sends rhythmic bioelectric impulses along specific conducting fibers to the heart muscle. These impulses stimulate the muscles to contract and relax in a regular sequence.

If the heart muscle fails to receive the pacemaker's signals, it will not pump the blood. With no blood reaching the brain, lack of oxygen will quickly cause an individual to lose consciousness. Within a few more minutes, the individual dies, unless the heart muscle is stimulated to resume its beating.

Today's pacemakers can weigh as little as one ounce (30 grams) and are relatively easy to install.

Artificial Pacemakers

The idea of using electric impulses to restart the heart goes back at least as far as 1862. The first practical idea was that of American inventor Wilson Greatbatch, who envisioned an implantable pacemaker in 1951. His idea, however, could not be practically implemented until transistors became widely available in the late 1950s. In 1960, after two years of animal testing, Dr. William Chardack and his associates implanted Greatbatch's device in the chest wall of a human patient.

Pacemakers operate only when episodes of irregular heartbeat occur. They can be programmed to vary the heart rate according to the body's needs. So, for example, a slower heart rate is programmed during sleeping hours.

In situations where a pacemaker is only needed for a short time (such as when a person's heart rhythm is temporarily disturbed by a heart attack), the pacemaker's generating unit can be worn externally on a belt, rather than implanted.

Design of modern pacemakers has continued to improve. Modern **lithium** batteries last up to 15 years, while earlier mercury-zinc batteries had a life of only 20 months. Today's pacemakers can weigh as little as one ounce (30 grams), and are relatively easy to install.

Pap test

The Pap test is a simple and relatively painless medical procedure used for the early detection of cancer in women.

The Pap test is a simple and relatively painless medical procedure for the early detection of cancer in women. The two most common and fatal forms of cancer are cervical and uterine. The test is considered to be one of the most effective weapons in the modern fight against cancer.

The test, whose full name is Papanicolaou's Smear, is named for George Nicholas Papanicolaou (1883-1962), the Greek-American doctor who developed it. In 1917, Papanicolaou began a microscopic study of vaginal discharge (fluid) cells in pigs in order to find out if the fluid contained any indications of disease in the animal. After expanding his research to humans, Papincolaou observed cell abnormalities in the discharge of a woman with cervical cancer. This observation inspired him to develop a method of detecting cancer through microscopic cell examination.

Papanicolaou's original findings were published in 1928, but his colleagues were quite satisfied with their standard method of taking a sample of cervical tissue to detect cancer. Unfortunately for patients, this procedure was longer and more painful. When Papanicolaou and his collaborator Herbert Traut published a monograph (a small, scholarly book) on the new procedure in 1943, it began to gradually gain acceptance.

The Pap smear allows detection of cancer even before symptoms are noted. In its earliest stages, cancer of the cervix is almost 100 percent curable. Also, 80 percent of cancers of the uterus detected by a Pap test can be cured. Every adult woman should have a pap test as part of a regular gynecological exam once a year.

Paré, Ambroise

Ambroise Paré (1510-1590) is widely considered the greatest surgeon of the sixteenth century. Renowned as much for his compassion as his surgical skill, Paré guided his life with a humble credo of patient care: "I dressed him, God cured him."

Paré was born in an era in which physicians considered surgery well beneath their dignity. Doctors left all cutting to the lowly barber-surgeons. Paré initially served as an apprentice to a barber in the French provinces, and at age 19 went to Paris where he became a surgical student at the famous Hôtel Dieu hospital. After his graduation in 1536, Paré joined the army as a regimental surgeon. He served intermittently in the army for the next 30 years, during which time he also developed a flourishing private practice and gained fame through his writings and his considerate, democratic treatment of soldiers of all ranks. Before his career ended, he had acted as surgeon to four French kings as well.

It was during the siege of Turin (1536-1537) that Paré made his first great medical discovery. Gunshot wounds, a new medical condition, were considered poisonous and routinely treated by cauterization (sealing off) with boiling oil. When Paré ran out of oil during the siege, he turned instead to simple dressings and soothing ointment, and immediately noted the improved condition of his patients. Paré popularized this revolutionary treatment in his *Method of Treating Wounds* in 1545.

Ambroise Paré.

Paré's next contribution to medicine was his promotion of ligature (tying off) of blood vessels to prevent hemorrhage (uncontrolled bleeding) during amputations. In a book on these new techniques, Paré also included large parts of **Andreas Vesalius**'s authoritative work on anatomy, translated from the original Latin into French. This information dramatically increased the barber-surgeon's knowledge of anatomy, since the typical barber-surgeon was never taught Latin as part of his training.

Paré was an innovator, always willing to try new practices. He favored massage and designed a number of **artificial limbs** as well as an artificial eye. He advanced obstetrics (the study of childbirth) by reintroducing podalic

version (turning a fetus in utero into a position possible for birth) and inducing premature labor in cases of uterine hemorrhage. As always, he spread knowledge of these discoveries through his writings.

Paré's greatest accomplishment, aside from actually coming up with new surgical techniques, was to spread this information throughout the barber-surgeon community, elevating surgery's status to a professional level and paving the way for vast improvements in surgical care.

[*See also* **Bandages and dressings**]

Pasteur, Louis

Louis Pasteur (1822-1895) is probably one of the best known nineteenth-century scientists. He is considered the founder of microbiology. Perhaps his most important work was the discovery of food **pasteurization** (sterilization) and the development of vaccines.

Early Life and Research

Pasteur was born in France and educated in Paris in the 1840s. He spent his career as a professor and researcher at several French universities. The main focus of his research was in organic (living) molecular structure and behavior. He was especially interested in fermentation, the process by which yeast transforms sugar into alcohol, as in the making of wine and beer, or the souring of milk and other perishable products. In the early nineteenth century there was no refrigeration to preserve delicate foods like milk and meat, so they spoiled quickly. No one really understood how and why.

Louis Pasteur.

In the course of his investigations into the function of yeast, Pasteur decided that some outside substances were taking over the natural fermentation process and ruining the product. He called these substances germs, and concluded that they were also involved in causing diseases by interfering with the body's biological processes in the same way as they interfered with yeast's biological activities.

Germ Theory and Pasteurization

These germ microorganisms were originally thought to appear out of nothing when milk or meat spoiled, so there seemed no way to get rid of them. Pasteur proved through many experiments that germs always came from other germs. If all the germs in a given product could be killed, and the product protected from future invasion, it would not spoil. Pasteur used heat to kill the germ microbes. The process he used, called "pasteurization," was named for him. It is still used to purify and protect perishable products such as milk.

Pasteur was not satisfied with this achievement. In the 1860s and 1970s, using his new germ theory, he discovered a parasite that was attacking silk worms. Pasteur also found the bacterium that caused anthrax (a disease that usually attacks domestic animals like cattle, but can also harm humans). He discovered that these germs could live in dead animal tissues and move through the air as spores (a small, single-cell reproductive organ often found in plants).

By properly sterilizing areas of infection, Pasteur showed how diseases could be stopped. Other researchers, such as the surgeon **Joseph Lister** (1827-1912), applied Pasteur's antiseptic techniques to operating room patients and greatly increased their survival rates.

Immunization

The science of immunization (vaccinating people and animals with weakened forms of a disease to provide immunity against the full form), also originated with Pasteur. He noticed that chickens that had been infected with an old, weakened versions of chicken cholera were immune to fresh cultures of the germs. Pasteur tried vaccinating cows with a weakened form of the anthrax bacterium, and found that they became immune to the disease.

Another scientist named **Edward Jenner** (1749-1823) had experimented with injecting humans with the cowpox germ in order to make them immune to smallpox, a serious disfiguring disease. In honor of Jenner's achievement, Pasteur proposed that the weakened cultures used for immunizing be called "vaccines," from the Latin word "vacca," meaning "cow."

Having worked on bacterial diseases, Pasteur then attacked the problem of rabies, a fatal disease often passed to humans by infected dogs (as well as other animals). In 1882, he discovered that rabies was caused by a very small germ, smaller than bacteria. Pasteur then developed a vaccine for rabies that worked both for animals and for humans.

Louis Pasteur became so famous that money poured into the institute named after him. He continued his work at the Pasteur Institute for the rest of his life. Thanks to Pasteur, we now understand how infectious diseases are spread, and through vaccinations, doctors have been able to save countless human lives in the twentieth century.

Pasteurization

Pasteurization is a process that uses heat to kill microorganisms. While the French chemist **Louis Pasteur** (1822-1895) first applied this process to wine, pasteurization is more usually recognized as being a treatment for milk.

Milk goes through the pasteurization process.

Pasteur was called upon to tackle some of the problems plaguing the French wine industry. Of special concern was the spoiling of wine. This caused great economic loss and tarnished France's reputation for fine vintage wines. Vintners wanted to know the cause of *l'amer,* a condition that was destroying the best burgundy wines. Pasteur looked at wine under the microscope and noticed that when aged properly, the liquid contained little spherical yeast cells. When the wine turned sour, however, there were numbers of bacterial cells producing lactic acid. Pasteur suggested heating the wine gently at about 120 degrees. This killed the bacteria that produced lactic acid and let the wine age properly.

A Second Revolution

Pasteur's book *Etudes sur le Vin* ("Studies Regarding Wine") was published in 1866. It was a testament to two of the researcher's great passions—the scientific method and wine. Pasteur suggested that greater cleanliness was needed to eliminate bacteria; this could be done with heat. Some wine-makers were aghast at the thought, but doing so solved the industry's problem.

Milk Joins the Revolution

With the practice of heating wine to kill bacteria firmly established, researchers turned to other liquids like milk. The idea of pasteurization was born. Several decades later in the United States, the pasteurization of milk was championed by American bacteriologist Alice Catherine Evans (1881-1975), who linked bacteria in milk with the disease brucellosis (a type of fever found in different variations in many countries). Pasteurization is now applied to most liquid food products produced commercially.

Patent medicine

Patent medicines first appeared in England in the 1600s. When a medication was patented, its formula was owned by the patent holder. No one else could duplicate and sell the medication. To qualify for a patent, a medicine only had to be original. It did not have to be either effective or safe. Because the ingredients of patented remedies had to be listed, many sellers of these types of products never applied for patents. Instead, they registered distinctive trade names in order to market their wares. The ingredients were unspecified but their brand name was unique. In time, all of these medicines being promoted for public sale became known as "patent

medicines," whether they were in fact patented or not. Most were promoted as astonishingly effective cures for an equally astonishing range of maladies. For example, an 1800s advertisement for "Dr. Jayne's Alternative" claimed that it cured at least 25 different ailments. These conditions ranged from cancer to skin problems.

Early British Patent Medicines

Among the earliest British patent medicines were "Anderson's Pills," "Daffy's Elixir", and "Lockyear's Pills," all of which date from the 1600s. In the 1700s came "Dr. Batemen's Pectoral Drops," "Dr. Hooper's Female Pills," and "Robert Turlington's Balsam of Life."

Early American Patent Medicines

As British subjects emigrated to America, they brought the concept of patent medicines with them. The first American-made medicine to be patented in Great Britain was "Tuscorora Rice." This product was invented by Mrs. Sibilla Masters and was actually made from Indian corn. Another early American nostrum was "Widow Read's Ointment for the Itch." This product was advertised by Read's son-in-law, Benjamin Franklin, in his *Pennsylvania Gazette* in 1731. Heavy national advertising would later be the prime means of promoting patent medicine sales in America. In 1796 the first patent issued in the United States for a medicine was granted. Samuel Lee, Jr. was the patent holder and his "Bilious Pills" promised to cure a score of ailments.

Patent Medicines of the 1800s

A popular cure of the 1800s was "Swaim's Panacea." This was a syrup of sarsaparilla introduced by William Swaim in 1820. Swaim ran a six-page advertisement for his Panacea in the 1832 *Farmers and Mechanics Almanac*. With his ad, he pointed the way toward a new advertising gimmick for patent medicines—the free annual almanac devoted to promoting an individual remedy. Dr. David Jayne launched his series *Medical Almanac and Guide to Health* in the 1840s to push such medicines as "Jayne's Sanative Pills," "Jayne's Vermifuge," and "Jayne's Alternative." The first *Hostetter's American Almanac* was published in 1860. It promoted the sale of "Doctor Hostetter's Celebrated Stomach Bitters." This was an unusual product because it had indeed been formulated by a real doctor.

A Popular Patent Medicine

Patent medicines flourished in the United States from the start. They were most popular in the latter part of the nineteenth century. Perhaps the best-known and most enduring among these was Lydia E. Pinkham's "Veg-

etable Compound." This remedy was devised by Mrs. Lydia Estes Pinkham (1819-1883) of Lynn, Massachusetts, to cure "female complaints." Mrs. Pinkham had been preparing her herbal concoction on her kitchen stove for years. The recipe was supposedly given to her by a machinist in payment of a debt. When the Pinkham fell into near poverty following the panic of 1873, Pinkham's son Dan suggested selling the compound. She produced the remedy and wrote advertising copy, along with a four-page booklet titled *Guide for Women*.

When the Pinkhams began advertising in the *Boston Herald* in 1876, a successful mail-order business flourished. When Pinkham's portrait was added to the Compound's label in 1879, sales escalated, and she became the most recognized woman in America. Letters poured in from women all over the country seeking medical advice. Their queries were answered by a staff of women supervised by Pinkham. The business remained in the Pinkham family until 1968, and the Compound was still being marketed in the 1980s.

Ironically, **Louis Pasteur**'s scientifically-based germ theory of disease was brought to the American public by the very unscientific claims of patent medicine peddlers. Chief among these was William Radam, a Prussian emigre residing in Texas. Inspired by Pasteur's discovery of the microbe, Radam developed a medication to fight the microscopic entities within the human body. The result was Radam's "Microbe Killer," patented in 1886. Its popularity was unshaken by analysis revealing it to be 99 percent water and of no real value.

New Marketing Techniques

Patent medicine makers always advertised and promoted their products heavily. The most colorful promotions were the traveling medicine shows and entertainments. These shows existed in colonial times, continued to grow in size and scope during the 1800s, and reached a climax in the 1880s and 1890s. The shows offered a variety of entertainment. Drama, vaudeville, circus, minstrels, and magic were used to pitch the product. The biggest and best-known shows were the "Kickapoo Indian" or Wild West shows staged by John E. Healy and "Texas Charley" Bigelow. As many as 75 Kickapoo shows toured the country at a time. Each troupe was staffed with half-a-dozen Native Americans, a "scout" and several others. An Indian "medicine man" would impressively describe the virtues of the particular remedy in his native language, while the "scout" interpreted his speech. Remedies included the popular "Kickapoo Indian Sagwa," plus "Kickapoo Indian Salve," "Kickapoo Indian Worm Killer," and "Kickapoo Cough Cure."

Phony Medicines

Another cure falsely attributed to Native Americans was Clark Stanley's "Snake Oil Liniment." Stanley claimed the product originated with the medicine men of the Moki Pueblo in Wolpi, Arizona. He started marketing his remedy in 1886 and promoted it by killing hundreds of rattlesnakes before audiences at the Chicago World's Fair of 1893. Analysis, however, showed that Stanley's liniment contained no rattlesnake oil.

Although patent medicines were very popular, concerns began to grow about their ingredients. Many had high levels of alcohol. Lydia Pinkham's, for example, was 19 percent alcohol. The widely sold "Dr. Kilmer's Swamp Root" was 12 percent, and "Hostetter's Bitters" was a dizzying 32 percent. Other products, including medicines for children, were laced with such addictive drugs as heroin, **opium,** and **cocaine.** These concerns led to the passage of the Pure Food and Drug Act of 1906. Patent medicines now had to list their ingredients on packaging labels. A supplementary law passed in 1938 required manufacturers to test their products for safety before marketing them; tests for effectiveness were required as of 1962.

Legitimate Patent Medicines

Not all patent medicines were of the "snake oil" variety. Some of the most familiar legitimate patent medicines originated in the late 1800s and early 1900s.

Listerine

Listerine, an antiseptic and disinfectant, was developed in 1879 by Jordan W. Lambert, cofounder of the Warner (later Warner-Lambert) pharmaceutical firm, and marketed to physicians. The product was named after **Joseph Lister** (1827-1912). Lister was the English physician who pioneered antiseptic surgery. Lambert's son, Gerald, introduced Listerine to the mass market in 1921. Advertising played heavily on the product's effectiveness in saving the user from the social scourge of halitosis (bad breath).

Other Popular Patent Medicines

In 1897 Felix Hoffmann found a way to synthesize acetylsalicylic acid. In 1899 the Bayer Company began marketing what was to become probably the most popular of all patent medicines, **aspirin.** New York chemist Charles Henry Phillips coined the name "Milk of Magnesia" in 1880 for his antacid, a white suspension of magnesium hydroxide in water. Lunsford Richardson, a North Carolina pharmacist, developed an external cold remedy in the 1890s that he called Richardson's Croup and Pneumo-

nia Cure Salve. When he renamed his product, sales of Vick's Salve, later Vick's VapoRub, skyrocketed. Ex-Lax, the laxative with a chocolate flavor, was the 1905 invention of a Hungarian-born New York scientist.

Modern-Day Patent Medicines

One of the more modern patent medicines, Alka-Seltzer, was introduced by Miles Laboratories in 1931. Alka-Seltzer is a tablet composed of an antacid, aspirin, and an agent formulated to bubble when immersed in a glass of water. In 1955 the Johnson & Johnson company marketed Tylenol, which uses acetaminophen to relieve pain and reduce fever. This product does the same thing as aspirin but does not cause the side effects. At first a prescription medication, Tylenol became an over-the-counter (OTC) product in 1960.

Penicillin

Penicillin is a chemical produced in common molds which has potent antibacterial properties. Bacteria are tiny organisms that have the potential to cause a huge variety of infections in every organ system of the human body. The accidental discovery of penicillin in the twentieth century may be one of the greatest milestones in medical history. Penicillin opened the door to a variety of new "miracle drugs" that have saved the lives of millions. Until the discovery of penicillin, the only treatments available for bacterial infections were quinine, arsenic and sulfa drugs. All of these were highly toxic (poisonous).

Fleming's Mold

Scottish bacteriologist **Alexander Fleming** (1881-1955) discovered penicillin by accident in 1928. While conducting research using several petri dishes of bacteria cultures, he accidentally left one of the cultures uncovered for several days. Fleming found the dish contaminated with a mold. He was about to discard the culture when he noticed that the mold was dissolving all the bacteria near it.

Fleming recognized the importance of what was happening. He put a sample of the mold under his microscope and tested it against several types of bacteria. Fleming found that something in the mold stopped or slowed the growth of the bacteria. Because the mold was from the genus Penicillium, Fleming named the part of the mold that attacked bacteria "penicillin." He was unable to separate the penicillin from the mold, however.

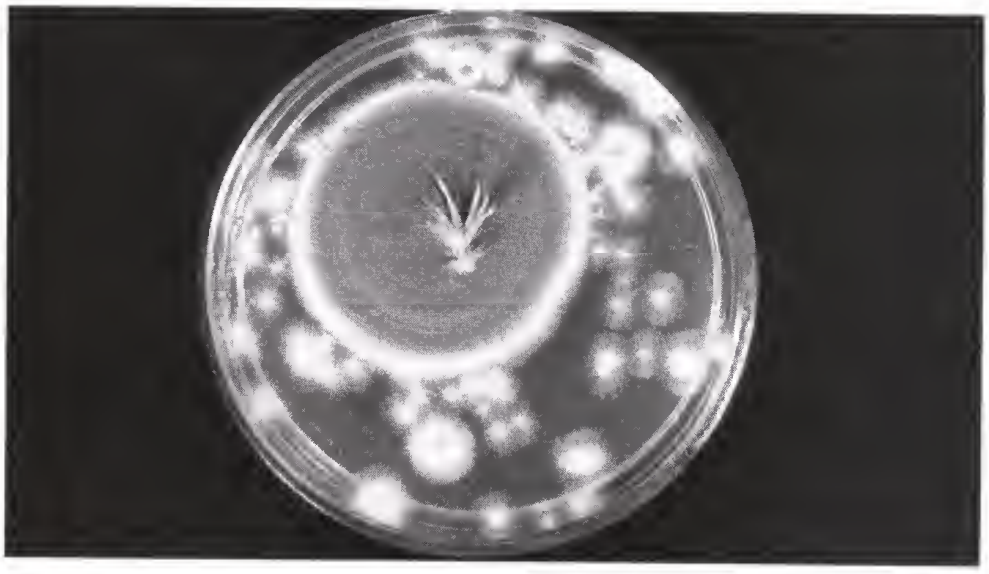
In 1935, at Oxford University in England, researchers **Howard Walter Florey** (1898-1968) and **Ernst Boris Chain** (1906-1979) stumbled across an article by Fleming about his work with penicillin. They obtained a culture (sample) of Fleming's original mold and were able to separate and purify the penicillin. Florey began testing the penicillin on animals and found that it was nontoxic (did not harm living cells) as well as an effective **antibiotic.** Furthermore, it did not interfere with the activity of white blood cells (the body's natural defenders against infection).

Penicillin in World War II

Trials of the drug on humans were so successful that great quantities of penicillin were used to treat infections suffered by wounded and ill soldiers during World War II (1939-1945). England was not able to manufacture penicillin in quantity because of its involvement in the war. Florey traveled to the United States and convinced the government to sponsor research on the mass production of penicillin. An efficient method of mass-producing penicillin was developed using fermentation and a cornstarch medium. This basic technique is still used to produce many antibiotics.

Penicillin prevented thousands of wartime deaths from gas gangrene and other infections. Now the race began to discover its molecular structure so that it could be produced synthetically (in a laboratory from its chemical compounds).

In the mid-1940s English researcher Dorothy Crowfoot Hodgkin (1910-) used **X-ray crystallography** and an early IBM card-punch computer to determine the chemical structure of penicillin. The door was now



A penicillin culture. Until the discovery of penicillin, the only treatments available for bacterial infections were quinine, arsenic, and sulfa drugs.

open to other scientists to develop methods to synthesize it. Robert Burns Woodward (1917-1979), an organic chemist at Harvard University, completed the first penicillin synthesis in the 1950s.

Penicillin is used to treat any number of infections, including syphilis, meningitis, and pneumonia. Penicillin has reduced the threat of bacterial infections. The capability to treat potentially life-threatening infections has permitted the development of surgical operations, organ transplants, and open heart surgery. It has also vastly improved the treatment of burns.

Because the discovery and development of penicillin is rightly regarded as one of the greatest achievements in medical history, many of the scientists who worked on it have been highly honored. Fleming, Florey, and Chain shared the 1945 Nobel Prize in medicine for the development of penicillin. For their work with penicillin as well as other research, Hodgkin and Woodward also received the Nobel Prize, in 1964 and 1965, respectively.

[*See also* **Antibiotic; Open heart surgery; Quinine**]

Pincus, Gregory

Endrocrinologist Gregory Pincus (1903-1967) is best known for developing the oral contraceptive, or birth control pill. He also investigated the biochemistry of aging, arthritis, cancer, and the adrenal system's response to stress.

Gregory Pincus.

Pincus was born in Woodbine, New Jersey. Both of his parents had interests in agriculture and the arts, and his father taught at an agricultural school. In 1924 Pincus graduated from Cornell University, where he not only studied science but founded a literary magazine. In 1927 he received master's and doctoral degrees from Harvard University.

After further study in Europe, Pincus joined Harvard's biology faculty. In 1938 he joined the faculty at Clark University, in Worcester, Massachusetts, as an experimental zoologist (a scientist who studies the behavior and lifestyles of animals). In 1944 he co-

founded the independent Worcester Foundation for Experimental Biology, where he continued earlier research on the way the reproductive system and female hormones worked.

Sex Hormones

Ever since the discovery of sex hormones, scientists had been searching for a safe, effective way to use these hormones to either increase a woman's chances of becoming pregnant, or keep her from getting pregnant at all. Several scientists in the 1920s proved that the hormone progesterone prevented ovulation (release of an ovum from the female), but it was very hard to synthesize for widespread use.

Subsidized Study

Birth control advocate **Margaret Sanger** (1879-1966) noticed Pincus's research and arranged to get him financial research support from philanthropist Katherine Dexter McCormick (1875-1967). In the 1950s, Pincus and his colleagues focused their efforts on developing a hormone combination that would fool the woman's body into thinking it was already pregnant, thus keeping any new ova (eggs) from being released.

Biologist Min-Chueh Chang carried out the experiments on laboratory animals. He worked with various compounds of progestin, a synthetic progesterone developed in Mexico by American chemist Carl Djerassi (1923-) and physician John Rock, who had already been experimenting with progesterone to cure infertility.

Tests of the new substance were carried out in several states, including California and Massachusetts. Because contraception was illegal in Massachusetts, the initial tests were to treat infertility rather than prevent pregnancy. In 1960 the compound was approved by the U.S. Food and Drug Administration as the first contraceptive pill. The pill was manufactured by G. D.Searle Company under the name Enovid. Enovid was sold only by prescription.

Gregory Pincus continues to be hailed as the primary force behind the oral contraceptive. Among the many honors he received during his lifetime was membership in the National Academy of Sciences.

Prenatal diagnostic techniques

Prenatal diagnosis is the process of determining the condition of a fetus (name given to unborn young from the end of the eighth week of devel-

opment through birth) before it is born. This type of diagnosis has become an important part of pregnancy care.

The earliest form of prenatal testing was very simple. The mother noted fetal activity in the womb, and the doctor manually felt the unborn child through the mother's abdomen. Eventually machines were developed for listening to the fetal heartbeat.

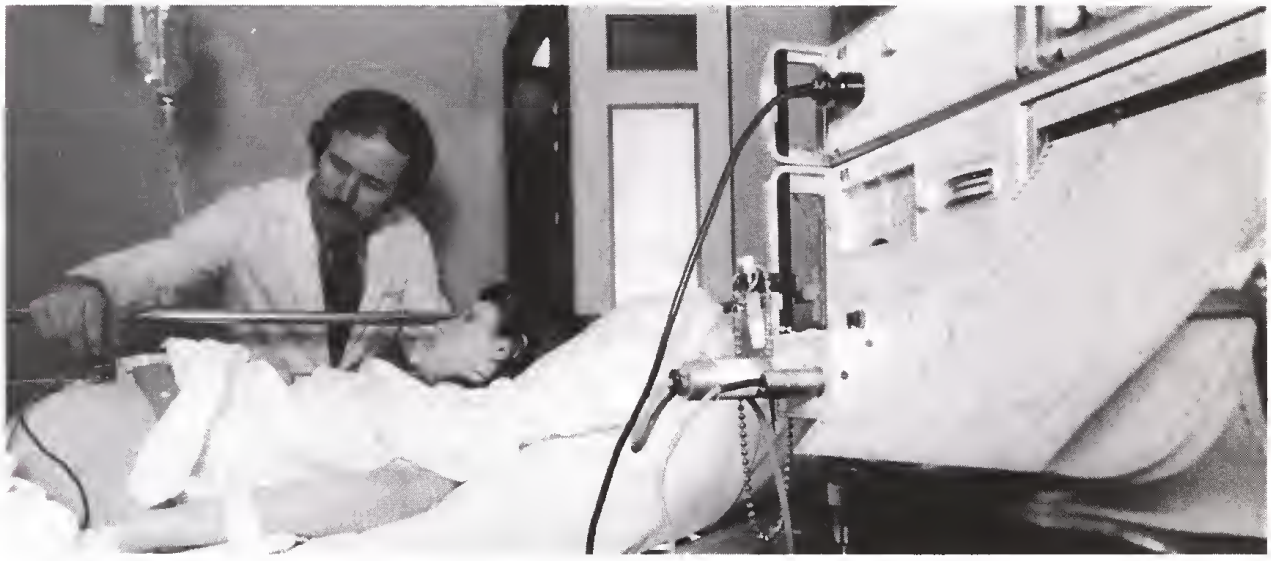
Amniocentesis

Prenatal diagnosis began to improve with the development of **amniocentesis** in the 1950s. In the 1960s the ability to culture cells from amniotic fluid was developed. Beginning in 1968, cells from amniotic fluid could be analyzed for chromosome disorders like Down's syndrome. Today, amniocentesis permits the diagnosis of a wide range of disorders. Amniocentesis is normally recommended at fourteen to sixteen weeks of pregnancy. Test results are usually available to the patient in two to three weeks.

Ultrasound

Ultrasound scanning has become the most popular method of prenatal testing. Ultrasound uses sound waves to produce a picture of the developing fetus. It has no known harmful effect on the mother or the unborn child and requires no probing or biological samples to be taken.

In 1977 so-called "real-time" ultrasound equipment became commercially available. The real-time mode shows detailed images of the moving fetus as the movement occurs. Real-time ultrasound was quickly applied to invasive (entering the body) prenatal diagnostic techniques. With



As this woman's labor progresses, an electronic sensor is attached to her abdomen to monitor uterine contractions and the fetal heartbeat.

these techniques, a needle is inserted into the womb to take samples. The samples might be of amniotic fluid, fetal blood, or chorionic villi. The needle can be visually guided by the real-time ultrasound. By being able to guide the placement of the needle, damage to the fetus is avoided.

Chorionic Villus Sampling (CVS)

Chorionic villus sampling is when samples of fetal tissue are retrieved from the fetus. The samples are then analyzed for chromosomal, biochemical, and DNA content. One method of obtaining the sample through the cervix was described by Jan Mohr (1921-) in 1968. This method was abandoned because of a high rate of complications.

In 1982 a British group at the University College Hospital of London developed a new technique. Transcervical CVS sampling (taking a sample through the cervix) guided by real-time ultrasound became a safe procedure. Transabdominal CVS sampling (taking a sample through the abdomen) was first reported in 1984 and is used in some cases to avoid vaginal infection. Ultrasound-guided CVS is now widely used. It can be performed much earlier in pregnancy than amniocentesis and results are available within a week.

Measuring Alpha-Fetoprotein (AFP)

Another prenatal diagnostic test now given to most pregnant women measures maternal serum alpha-fetoprotein (MSAFP) levels. This test samples the mother's blood for the amount of AFP. AFP is a protein produced by the fetal liver. As levels of AFP in the mother's blood mirror the levels in the fetus, testing has been rapidly expanded to include more women. In 1984 it was reported that low MSAFP levels were associated with Down's syndrome. With this information, the need for more detailed testing can be identified earlier during the pregnancy.

Fetal blood sampling has been done since 1972. The sample is used to diagnose a variety of hereditary blood disorders. This procedure was improved upon by Fernand Daffos and his team in 1982. The group developed a method of retrieving samples of blood from the umbilical cord. They used a needle guided by real-time ultrasound imaging. This procedure is called cordocentesis, or percutaneous umbilical blood sampling (PUBS).

DNA Analysis

DNA analysis for specific **gene** disorders was introduced to prenatal testing in 1976. DNA from a number of different sources is examined. These sources include fetal samples plus maternal and paternal blood sam-

ples. This allows the doctors to identify genetic problems that might be transmitted by either parent. Over 260 single gene defects can now be diagnosed through DNA analysis, and the list continually grows.

Other New Procedures

Prenatal diagnostic testing is rapidly expanding. Nuclear magnetic resonance imaging (**MRI**) and spectroscopy (NMR) are new tools. The tests reveal biochemical information about fetal soft-tissue and organ structure and function. Fetal tissue sampling is an experimental technique. It is used to detect very rare hereditary and fatal skin disorders. Another not-yet-perfected experimental procedure is cell sorting. In cell sorting, fetal cells are isolated from the maternal blood for analysis. Prenatal testing is even carried out on some embryos, eggs, and sperm before in-vitro implantation.

After Diagnosis

Prenatal diagnosis is now moving in the direction of prenatal treatment. The field of **prenatal surgery** is in its infancy. A few conditions identified prenatally can be treated in the womb successfully by medicating the mother. Respiratory distress syndrome is one of these conditions. It is a prime killer of prematurely born infants. Another condition is methylamalonic acidemia. This is a rare vitamin metabolism defect.

Prenatal surgery

Prenatal surgery is an invasive procedure performed on a fetus (name given to unborn young from the end of the eighth week of development through birth). An invasive procedure is one in which the fetus is penetrated by an instrument. The first successful fetal operations were carried out in the 1920s on various animal subjects. Surgical experiments continued for the next four decades.

The first human fetal surgery was performed in the 1950s. It involved a **blood transfusion** to a fetus with a condition called "Rh incompatibility." In this condition, the fetus's Rh-positive red blood cells are destroyed by its Rh-negative immune system.

Ultrasound Makes Amniocentesis Possible

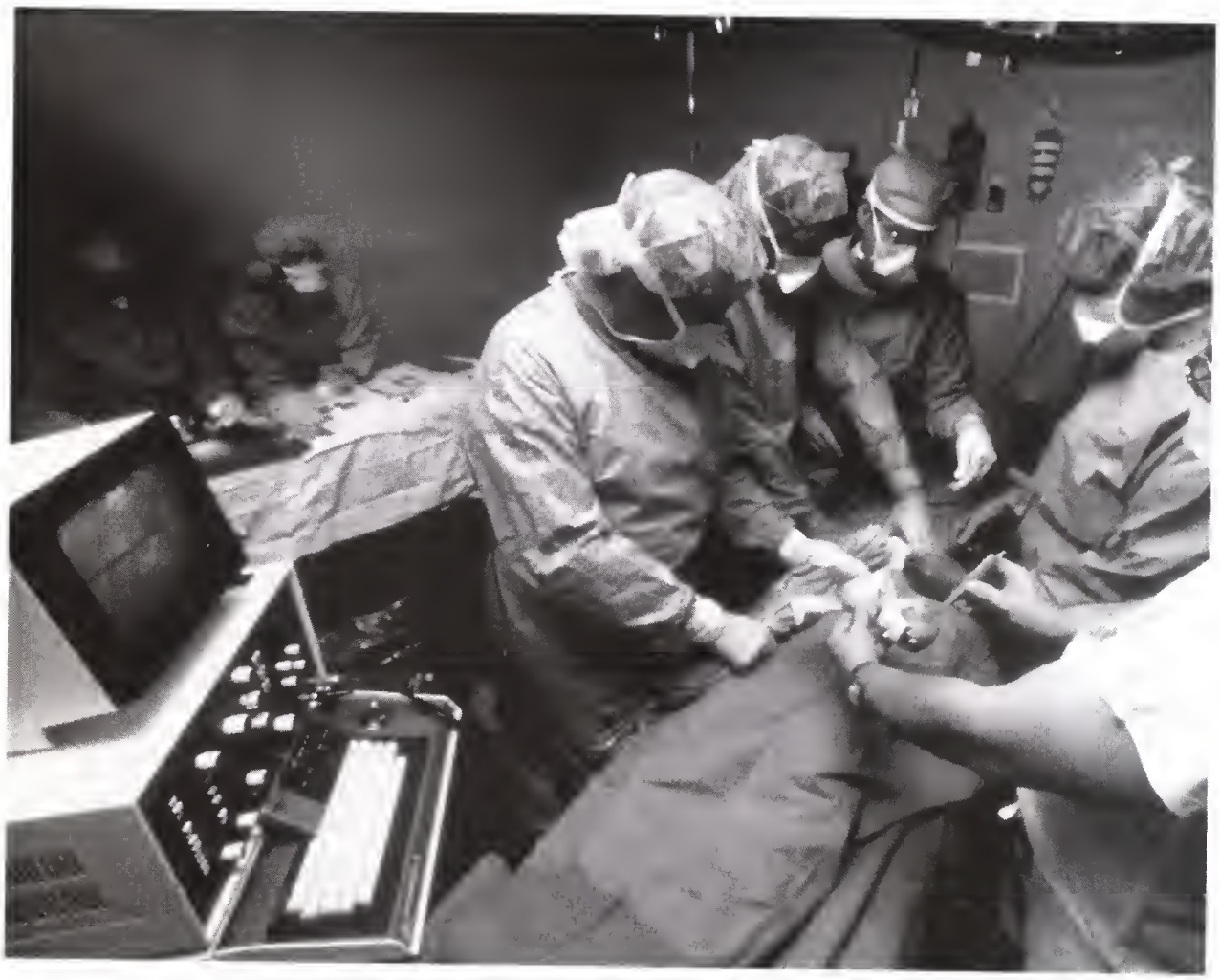
Ultrasound imaging was developed in 1977. Ultrasound devices bounce soundwaves off an object and draw a picture based on how deep the

Prenatal surgery

sound waves go. The ultrasound provides a photographic image of the developing fetus, making practical the procedure known as **amniocentesis.**

In amniocentesis, a hollow needle is inserted through a pregnant woman's abdomen into the amniotic sac that surrounds the fetus. A sample of amniotic fluid is removed and examined for evidence of genetic abnormalities like Down's syndrome.

Successful open-womb surgery was pioneered by pediatric surgeon Michael Harrison of the University of California at San Francisco. In 1982 Harrison performed his first open-womb operation. The operation was to correct a urinary tract obstruction that affects 1 in 2,000 male fetuses. In 1989 Harrison operated to repair a hole in the diaphragm of a 24-week-old fetus. This is a very serious malformation which is frequently fatal. The fetus's arm was pulled out through an incision in the mother's abdomen and uterus. The fetus's misplaced internal organs were repositioned, and



Doctors perform prenatal surgery on a fetus with hydrocephaly, a congenital condition in which an abnormal amount of cerebral fluid in the skull puts extreme pressure on the brain.

the mother's incisions were patched with GoreTex. The baby was born seven weeks later, premature but healthy.

Prenatal surgery remains in its earliest stages of development. The success rate is not yet high. Some of the procedures with higher success rates include amniocentesis and the bladder shunt performed by Harrison. The risk remains high for both fetus and mother. One surgical technique that has exciting possibilities is fetal stem-cell transplantation. This involves injecting stem cells, the earliest precursor of all blood cells, from a dead fetus into a live one. This provides the living fetus with healthy genetic material to overcome defective **genes** of its own.

[*See also* **Blood transfusion; Gene; Ultrasound devices**]

Quinine

Quinine is an alkaloid found in the bark of the cinchona tree. Quinine has been used to treat malaria (a recurring disease marked by severe chills and fever) since the early 1600s. It was the best chemotherapeutic (chemical therapeutic) agent available to combat the disease until the 1920s. Malaria treatment by quinine marked the first successful use of a chemical compound to treat an infectious disease.

The Discovery of Quinine

Quinine has been referred to as "Jesuits' bark," "cardinal's bark," and "sacred bark." Its name stems from its use in 1630 by Jesuit missionaries in the Andes (a mountain range in western South America). A legend suggests earlier use by the native population. According to the legend, an Indian with a high fever was lost in an Andean jungle. When he drank from a pool of stagnant (standing) water, he found it tasted bitter. Realizing it had been contaminated by the surrounding quina-quina trees he thought he was poisoned. But his fever abated, and thereafter his village used extracts made from quina-quina bark to treat fevers.

The legend of quinine's discovery accepted in Europe involves the Countess of Chinchon, who had visited Peru. While in Peru the countess contracted a fever which was cured by the bark of a tree. Returning to Spain with the bark, she introduced quinine to Europe in 1638. In 1742 Swedish botanist Carol Linnaeus (1707-1778) called the tree "Cinchona" in her honor. The legend is a bit faulty. In fact, the Countess never had malaria and died in Colombia before reaching Spain.

Synthesizing Quinine

Malaria is a lethal disease worldwide. Because it is so widespread, the potential value of quinine inspired research into its synthesis. In 1820 French chemist Pierre-Joseph Pelletier (1788- 1842) and Joseph-Bienaimé Caventou (1795-1877) isolated quinine from cinchona bark. In 1908, P. Rabe theorized the correct chemical structure of quinine. This structure was not confirmed, however, until 1944 when American chemist Robert Burns Woodward (1917-1989; 1965 Nobel Prize winner in chemistry) and William von Eggers Doering first successfully synthesized the chemical. This was an amazing achievement of synthetic organic chemistry, but of little commercial value as the cost of the process was too high to be practical.

In the beginning of the twentieth century most of the naturally produced quinine originated in Java, now part of Indonesia. During World War I (1914-1918), Germany was cut off from supplies of quinine and developed the synthetic substitute Atabrine. By 1942 when the United States entered World War II (1939-1945), the Javanese plantations were controlled by Japan. American soldiers fighting in North Africa and the South Pacific islands were devastated by malaria. White pills taken from captured Italian soldiers were sent back to the United States. They were found to be the synthetic antimalarial drug chloroquine. The drug was manufactured by the same German lab as Atabrine. The United States was then able to synthesize several tons of its own before the end of the war.

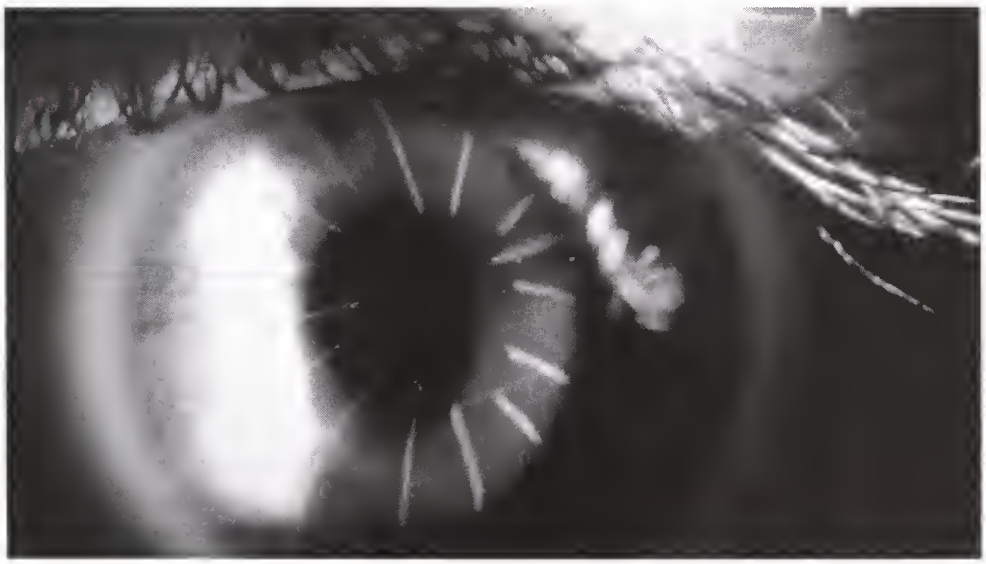
Today, both chloroquine and Atabrine are used to prevent malaria. There are areas of the world, however, where malaria parasites have developed a resistance to synthetic drugs. Vietnam is one of those areas. For those cases, quinine is still effective in malaria treatment.

[*See also* **Chemotherapy**]

Radial keratotomy

Radial keratotomy is a surgery performed on the covering of the eyeball (the cornea). It is used to permanently correct near-sightedness, or myopia. In myopia, light rays entering the eye's lens are bent too much. The rays focus in front of, instead of onto, the back of the eye, or the retina. In radial keratotomy, incisions made on the cornea to refocus the light rays.

The first radial keratotomy was performed in Japan in 1955. Like most new techniques, it was considered a risky procedure. Procedures were improved in the 1990s and many patients have successfully undergone the surgery.



Radial keratotomy. The procedure is used to permanently correct near-sightedness, or myopia.

Interviews with hundreds of patients show that after surgery, two-thirds of them were able to stop wearing **eyeglasses** or **contact lenses.** Some patients however, still needed lenses because they did not get the proper amount of correction. If there is not enough correction, the patient continues to have myopia. Too much correction however, causes far-sightedness. Further refinements are being made in the procedure to eliminate these undesirable results.

Corneal sculpting, also known as **laser surgery,** corrects myopia in about 30 seconds. While the procedure is being performed in other countries, it is not approved for use in the United States.

Radioimmunoassay (RIA)

Radioimmunoassay (RIA) is a sensitive method for measuring very small amounts of a substance in the blood. Radioactive versions of a substance, or isotopes of the substance, are mixed with antibodies and inserted in a sample of the patient's blood. The same non-radioactive substance in the blood takes the place of the isotope in the antibodies, thus leaving the radioactive substance free.

The amount of free isotope is then measured to see how much of the original substance was in the blood. This isotopic measuring method was developed in 1959 by two Americans, biophysicist Rosalyn Yalow (1921-) and physician Solomon A. Berson (1918-1972).

History

Yalow and Berson developed the first radioisotopic technique to study blood volume and **iodine** metabolism. They later adapted the method to study how the body uses **hormones,** particularly **insulin,** which regulates sugar levels in the blood. The researchers proved that Type II (adult onset) diabetes is caused by the inefficient use of insulin. Previously, it was thought that diabetes was caused only by a lack of insulin.

In 1959 Yalow and Berson perfected their measurement technique and named it radioimmunoassay (RIA). RIA is extremely sensitive. It can measure one trillionth of a gram of material per milliliter of blood. Because of the small sample required for measurement, RIA quickly became a standard laboratory tool.

How RIA Works

As an example of how this technique works, let's apply it to insulin. To measure insulin, the first step is to mix known amounts of radioisotope-tagged insulin and antibodies. These combine chemically. Next, a small amount of the patient's blood is added. The insulin contained in the blood displaces some of the tagged insulin. The free-tagged insulin is then measured with isotope detectors and the patient's insulin level is calculated.

Uses for RIA

RIA has many uses, including narcotics (drug) detection, blood bank screening for the hepatitis (a highly contagious condition) virus, early cancer detection, measurement of growth hormone levels, tracking of the leukemia virus, diagnosis and treatment of peptic ulcers, and research with brain chemicals called neurotransmitters.

Radiotherapy

Radiotherapy is the treatment of disease with radiation. Doctors use radiotherapy most often to treat certain kinds of cancers. The method of radiotherapy familiar to most people is **X-ray** treatment. X-ray radiation, however, can only show dense materials such as bone. A better way of diagnosing internal disorders is through the use of radionuclides, or radioactive tracers (isotopes).

Radioactive Isotopes

Radioactive tracers that are introduced into the body by injection are called radiopharmaceuticals. According to the type of radionuclide, the tracer will collect in one or more areas of the body. Since the tracer emits radiation, it is easily tracked by a Geiger counter (a device that measures radioactive levels) or scanning device. Because the tracer sends out information for a long time, doctors can follow its path through the body and check to see if organs are working properly.

Radioactive trace elements are a favorite diagnostic tool because they can be used to target individual organs, like the kidney. The trace elements also give off less radiation than a standard x-ray, so they are generally safer to use.

Beta and Isotope Injection Therapy

Once a radiotherapy diagnosis has been made, the doctor has a choice of treatments. For cancers near the skin surface, a stream of beta particles

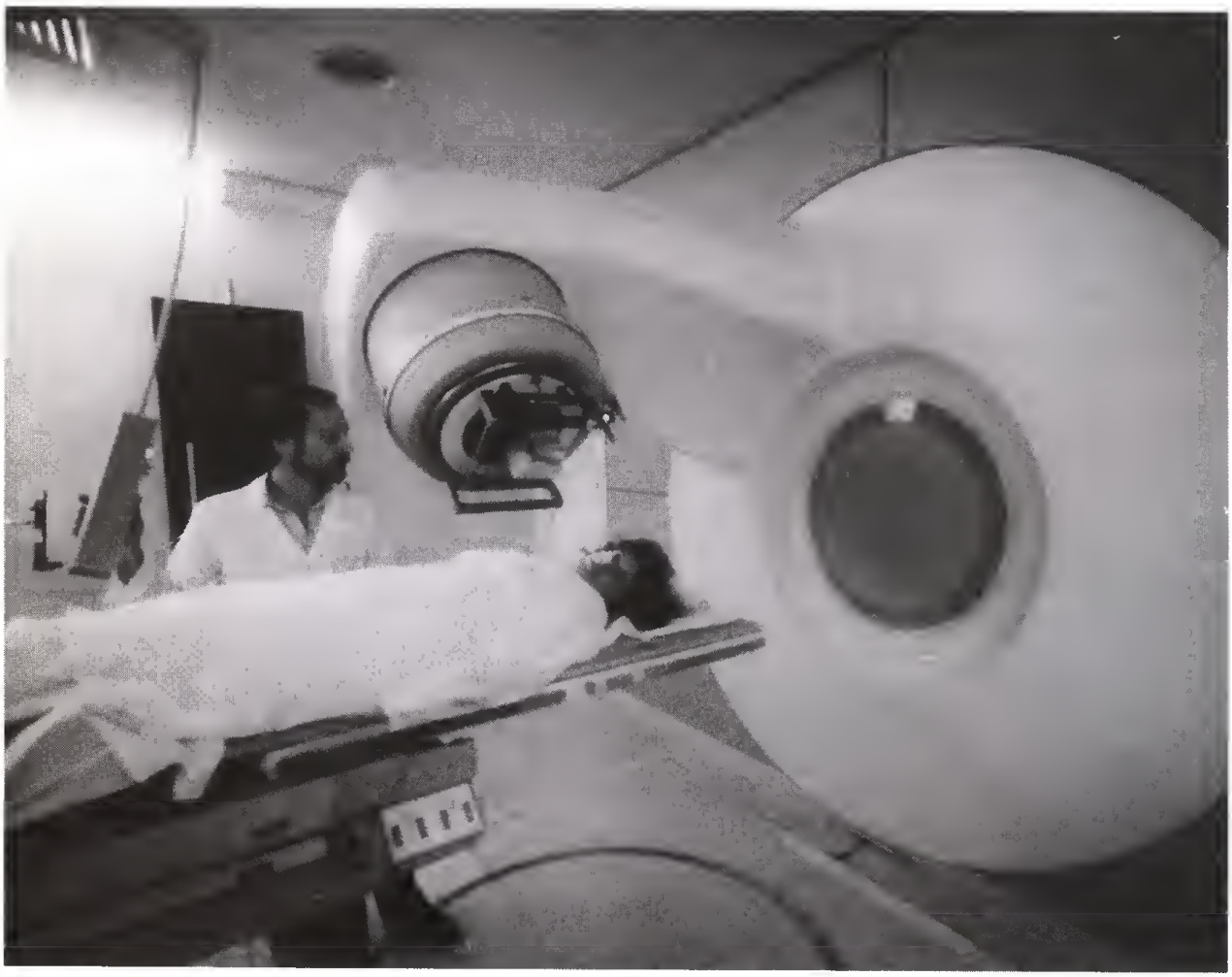
is used to kill cancerous cells. For cancers in a body organ, an isotope such as radioactive **iodine** is injected into the patient. The doctor will leave the isotope in the body until it has killed the cancer cells. The tracer is then flushed from the body before it can do permanent damage.

Edith Quimby

The person most responsible for the use of nuclear medical procedures is Edith Quimby, an American radiologist. Quimby was the first researcher to accurately measure the amount of radiation necessary to allow body traces. She later determined the exact dosages needed to use radiation as a diagnostic tool.

Other Uses

In addition to diagnostic applications, radiotherapy is used to sterilize medical instruments. Because it can be applied at very low tempera-



A patient receives radiation therapy. The method of radiotherapy familiar to most people is X-ray treatment. X-ray radiation, however, can only show dense materials such as bone.

tures, radiation can be used to sterilize plastic instruments that might be destroyed by steam. In addition, the radiation can reach all areas of an instrument, including small cervices, that traditional steam treatments often misses.

[*See also* **X-ray machine**]

Retinography

Retinography is a sophisticated means for identifying people by the pattern of blood vessels on the retina (the innermost coat of the back part of the eye). It requires the use of a special scanner about the size of a shoebox that can map the unique pattern of blood vessels on the retina. The pattern is so complex that even identical twins do not have the same blood vessel configuration. Those who favor its use claim retinography has an error rate of only one in a million.

There are currently a number of biometric devices in use, machines that can identify people by their physical characteristics. Some examples include fingerprint scanners and devices that can recognize a particular voice, hand, or signature. The retinal scanner is another addition to the identification tool kit.

How Retinal Scanning Works

A retinal scanner uses infrared light for mapping. As a person looks into the eyepiece, an invisible beam of low-energy infrared light traces a circular path on the retina at the back of the eye. The blood-filled capillaries absorb more of the infrared light than the surrounding tissue. Because of this, there is a variation in the intensity of the reflection. The scanner measures this reflection at 320 points along the beam path. It then assigns an intensity grade between zero and 4,095. The resulting numbers are compressed into an 80-byte computer code. This code can then be compared with patterns that have already been entered into the computer's data base.

Applications

Retina scans are already in use in the Pentagon and government and corporate organizations where people need to be identified before they can enter an area. New concerns about security from terrorism and bank and credit card fraud have caused many organizations to think seriously of using retina scans or other biometric means to identify people at airports and ATM machines.

Some states require that truck and bus drivers be mapped by retinography. This information is used by state agencies to prevent bad drivers from holding licenses in several states to hide their driving records. A proposed—and more controversial—use of retina scans is to develop a worker registry, where everyone is scanned to make sure that they are legal citizens of the United States, and thus eligible for employment. Critics of this proposal are concerned about possible invasions of privacy and violations of other personal rights.

Advantages and Disadvantages

Retinal scanners have several advantages over fingerprinting and voice recognition systems. They do not require as much computer memory as a fingerprint scan, and they are not subject to contamination from dirt or finger misplacement. Unlike voice recognition systems, retinal scanner are not distracted by background noise or changes in voice caused by illness.

The main disadvantage of the retinal scanner is that the person has to focus on the scanner from about three inches away. This restriction makes the device difficult for ATM use because a person using a cash machine rarely focuses on one area very long and is never close enough. A new device called an iris scanner may prove more useful for these casual transactions, since the scanning camera can be farther away and only has to scan the pattern of the iris (colored portion) of the eye, a procedure which does not require focusing on the camera.

Rh factor

Rh factor is also called "Rhesus factor" because it was first discovered in the blood of Rhesus monkeys (small monkeys from India often used for experimentation). Rh factor is an antigen, a substance which stimulates the production of antibodies to fight foreign invaders, such as viruses, bacteria and transplanted organs. A given individual either has the antigen already in their blood (they are Rh positive), or they don't (they are Rh negative). A patient's Rh status effects how he or she handles **blood transfusions** or organ **transplants.**

History

Prior to the twentieth century, blood and its function was poorly understood. In trying to solve the problem of serious blood loss from

injuries, doctors tried to inject (transfuse) blood from another person or animal into the injured patient. In some cases, this worked and the patient recovered. In many more cases, however, the blood transfusion actually harmed the patient, often causing death. No one could predict which type of reaction would occur as a result of a blood transfusion. So, by the beginning of the nineteenth century, most European nations had outlawed the practice of blood transfusion.

About 1900 Austrian-American physician Karl Landsteiner (1868-1943) developed an explanation for the phenomenon of blood rejection. Landsteiner found that human blood serum (the liquid portion of blood surrounding the cells) could be divided into four categories, depending on its ability to cause clotting of red blood cells. He gave these groups the names A, B, AB, and O based on what type of clotting antigen they had, if any.

In 1940 Landsteiner discovered another of blood factor antigen, known as Rh. This discovery resulted from Landsteiner's studies with Rhesus monkeys. Landsteiner and his colleagues found that when blood from monkeys was injected into rabbits and guinea pigs, it clotted. This was because of the presence of another antigen that the researchers had not classified before. Landsteiner called this antigen the Rh (Rhesus) factor. Researchers also showed that the factor occurs among some, but not all, humans. It is also inherited.

Importance of Rh Factor

The Rh discovery had immediate practical importance because it explained a relatively common medical disorder known as erythroblastosis fetalis. In this condition, an Rh-negative woman who becomes pregnant with an Rh-positive fetus (an unborn child) sometimes develops antibodies against the Rh factor in the fetus. This development usually causes no problem during the woman's first pregnancy, since the number of antibodies produced tends to be small.

By the time a second pregnancy occurs, the situation has changed. The number of Rh antibodies produced by the mother's body has become large enough to cause destruction of red blood cells in the fetus. This can result in complications such as anemia (a chronic blood condition characterized by lack of energy), jaundice (a condition in which bile pigments build up in the blood and cause skin, eyeballs and urine to take on a sickly yellow tone) or premature birth. Today, this reaction can be controlled by immunizing Rh negative women after their first pregnancy with a drug known as RhoGam.

RU 486

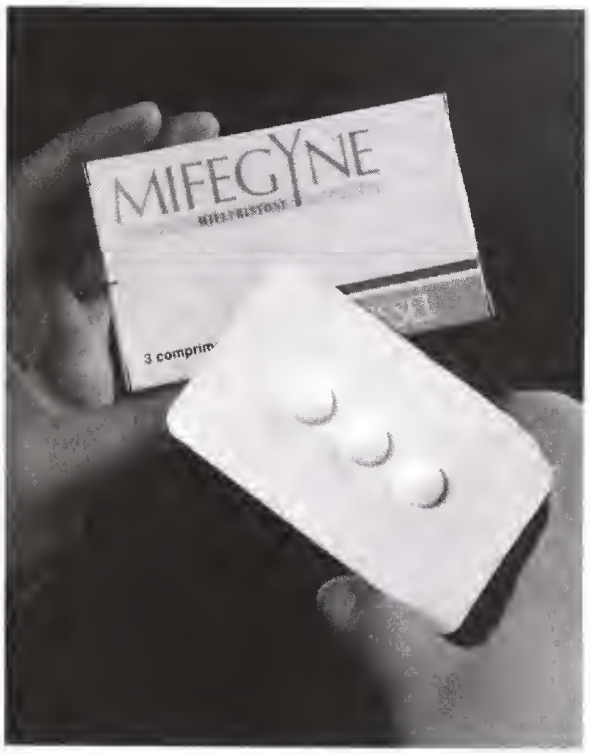
RU 486, also known as the "abortion pill," is considered one of the most controversial medical breakthroughs of recent times. (**Abortion** is the termination of a pregnancy and expulsion of the embryo or fetus from the uterus.) The pill was developed by French biochemist Etienne-Emile Baulieu (1926-). Baulieu spent more than 30 years researching **hormones.** A highly respected researcher, Baulieu co-founded the International Society for Research in Biology and Reproduction. He received international attention in 1988 when RU 486 was introduced to the public.

How RU 486 Works

RU 486 is an "antihormone" which blocks the effects of progesterone. Progesterone is a hormone that allows an embryo to develop in the uterus. RU 486 causes the fertilized egg and uterine lining to separate from the uterine wall. They are then both expelled through the vagina.

After developing the RU 486 **steroid** (fat soluble compound) in 1980, scientists conducted numerous tests on animals. The drug was found to be nontoxic. In 1985 extensive tests on human volunteers were carried out in five different countries. RU 486 was found to be safe and effective. It is designed for use in the first eight weeks of pregnancy. When a low dose of the hormone-like substance, prostaglandin, was given following RU 486, the success rate for pregnancy termination rose to 96 percent.

RU 486, also known as the "abortion pill," is considered one of the most controversial medical breakthroughs of recent times.



Controversy

In September 1988 RU 486 was approved for use in France (where abortion has been legal since 1975). Only one month after its introduction, the manufacturer of RU 486, Roussel-UCLAF, withdrew the drug from the market because anti-abortion activists had threatened a boycott of the company's products. In response to rising protests from members of the World Congress of Obstetrics and Gynecology, the French government then ordered the company to release the drug to state-controlled clinics. Within a year, about one-fourth to one-third of all early abortions in France were conducted with RU 486.

Baulieu staunchly defends his invention as a safe option for women who choose to end a preg-

nancy. He calls RU 486 a "contragestion" medication. Among its benefits are the fact that it is more private pregnancy termination option that poses far fewer medical risks than surgical abortion procedures.

In September 1989 Baulieu was given the Albert Lasker Award for his work. Following the death of a French woman who had used RU 486 in 1991, Baulieu introduced further refinements that he says make the drug safer. Because of its controversial nature and despite its safety, RU 486 is still not legal for use in many countries in the world, although it may soon be legally available in the United States.

[*See also* **Birth control; Sex hormones**]

Sabin, Albert Bruce

Albert Sabin (1906-1993) developed the "live" polio vaccine, beating rival **Jonas Salk**'s "killed" virus vaccine. Sabin's vaccine is widely used and has saved many from the paralysis associated with polio.

Sabin was born in Bialystock, Poland (then part of Russia) and emigrated with his family to the United States in 1921. He attended New York University, received his medical degree in 1931, and began research on the virus that causes polio. Known at the time as infantile paralysis, polio was a source of much fear because of its ability to cause paralysis and death, especially in infants and young children.

Polio Studies

By 1936 Sabin and his colleagues were able to grow the polio virus in human tissue cultures outside the body. In 1941 Sabin established that the human polio virus enters the body via the digestive tract and not the nose as was then thought. World War II (1939-1945) interrupted Sabin's polio research. While in the Army, he studied several diseases affecting American troops, such as sandfly fever, dengue fever, toxoplasmosis, and encephalitis lethargica. After the war, Sabin returned to polio research.

By 1954 Sabin had developed a vaccine that gave protection against polio using a live virus rather than the killed virus used by Salk. Sabin believed that an attenuated (weakened and harmless) live virus would provide more rapid and longer-lasting protection than the Salk method. As some professional rivalry developed between Salk and Sabin, Sabin per-

sisted in bringing his vaccine to completion. It became available to the public in 1961 following four years of worldwide tests. T

Advantages

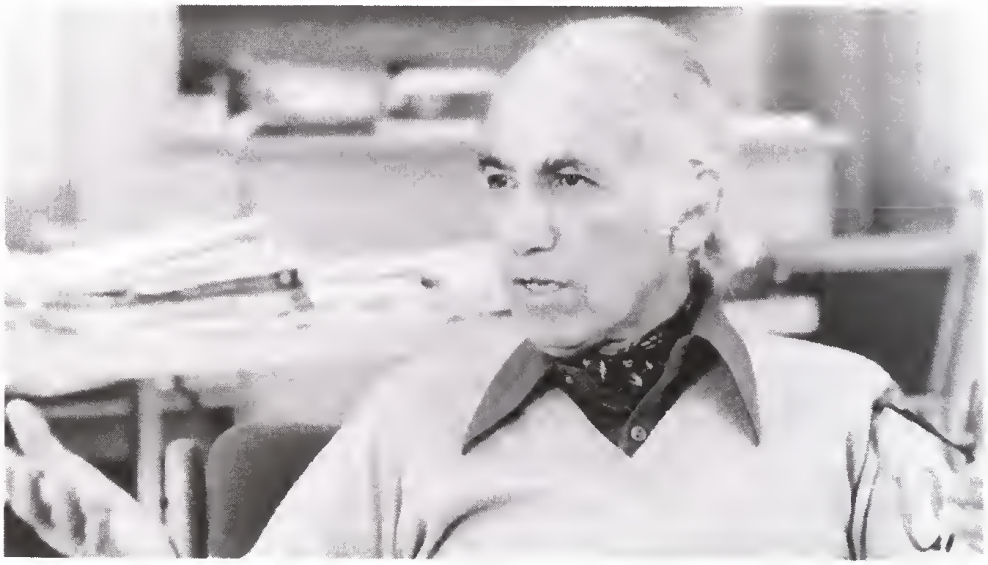
The Sabin vaccine has two advantages over the Salk vaccine. It can be administered orally (by mouth), rather than by injection, and offers protection with a single dose. Today, except for a few special cases, it is the preferred polio vaccine worldwide.

The development of the Sabin vaccine was the result of 20 years of research on the nature, transmission, and distribution of three related virus types. Throughout his professional career, Sabin was known for his tireless and brilliant research. In his later years, Sabin's interests led him to research the possible connection between viruses and human cancer. Sabin died March 3, 1993 at the age of 86.

Salk, Jonas E.

Jonas Salk (1914-1995) developed the first safe and effective vaccine for polio, a disease that killed or paralyzed many victims, particularly children.

Salk was born in New York City and received his medical degree from New York University in 1939. In 1942 he began working for a former teacher, Thomas Francis, Jr., to produce influenza (flu) vaccines, a project that continued until 1949. That year, as a research professor, Salk



Jonas Salk.

began a three-year project sponsored by the National Foundation for Infantile Paralysis (Polio), an organization also known as the March of Dimes.

Periodic outbreaks of polio, which attacks the nervous system, often caused death or a lifetime of paralysis, especially in children. It was a difficult disease to study because sufficient virus samples were hard to obtain and keep for study. Unlike bacteria, which can be grown in cultures, viruses need living tissue on which to grow. Once a method for preparing viruses was discovered and improved, enough material became available for research.

Three Viral Types

Salk first set out to confirm that there were three virus types responsible for polio. He then began to experiment with ways to kill the virus and yet keep its ability to produce an immune response. By 1952 he had produced a "dead" virus vaccine that worked against the three virus types. First the vaccine was tested on monkeys, then on children who had recovered from the disease, and finally on Salk's own family and children, none of whom had ever had the disease. Following large-scale trials in 1954, the vaccine was finally released for public use in 1955.

The Salk vaccine was not the first vaccine against polio, but it was the first to be found safe and effective. By 1961, there was a 96 percent reduction in polio cases in the United States. In the 1960s, the Sabin "live-virus" vaccine, developed by **Albert Sabin** (1906-1993), began to replace the Salk vaccine because it was given orally (by mouth) rather than by injection. The Salk vaccine, however, is still considered a triumph of medical science. In more recent years, Dr. Salk directed research in developing vaccines against cancer and AIDS. He died at the age of 80 in 1995.

Sanger, Margaret

Margaret Sanger (1883-1966) was the founder of the birth-control movement in America. She fought long-established attitudes about **birth control** and provided information to women, both rich and poor, about birth control methods.

Sanger was born Margaret Higgins in Corning, New York. She trained as a nurse in White Plains and Manhattan. In 1900 she married William Sanger and kept his last name, even after divorcing him and getting remarried.

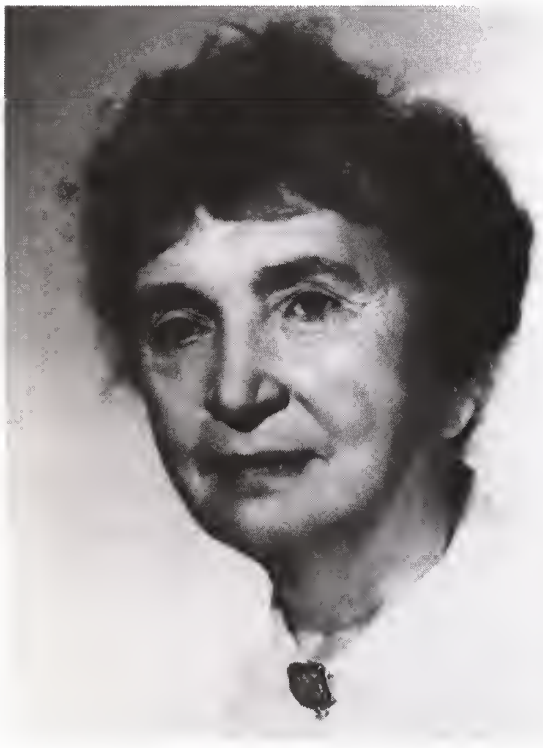
Planned Parenthood

In her nursing work in New York City, Sanger saw much suffering among the poor due to a lack of birth control information. Deaths from self-induced **abortions** and high infant mortality were commonplace. In large part because of what she witnessed, Sanger decided to devote her life to making birth control information—including material about safe birthing practices—and products available to anyone who wanted them.

In 1914, Sanger founded the National Birth Control League, an organization that offered lectures and print information about birth control. Soon after forming the National Birth Control League, Sanger was arrested for distributing birth control information in violation of the Comstock Law (a law named for anti-vice crusader Anthony Comstock which made it illegal to distribute or mail information about sexual topics, including birth control). After her release, Sanger founded the American Birth Control League in 1921. This organization eventually became the Planned Parenthood Federation of America.

Work Overseas

Not content to change attitudes about birth control in America, Sanger expanded her crusade with a World Population Conference in Switzerland in 1927. She later went to India and Japan to promote family planning.



Margaret Sanger.

Sanger continued to be controversial, even after laws were changed that made it easier to obtain birth control products. Some critics claimed that Sanger just wanted to make sure that poor, uneducated people—the focus of much of her early work—never got the chance to reproduce. Her personal life was also controversial. She was divorced in a time when it was frowned upon and stated that she didn't believe marriage was a sacred institution. She also believed in free love and free (or open) sexual relations.

Controversial attitudes aside, Sanger's courage and persistence in advocating birth control choices gave women the freedom to plan their families, improve their health by avoiding risky pregnancies, and pursue interests and talents outside the role of motherhood.

Schick test

During the late 1800s, a diphtheria epidemic killed thousands of children in western Europe and the United States and spurred research into ways of controlling the disease. Diphtheria is a contagious disease caused by a bacterium.

Diphtheria is spread through respiratory droplets in infected individuals. The droplets are scattered and passed to other people through sneezing and coughing. The bacteria go to the mucous membranes of the throat and secrete (release) a potent toxin (poison) which causes tissue destruction and the formation of a gray membrane (a thin covering) in the upper respiratory tract. This membrane can loosen and cause the patient to suffocate (die from lack of oxygen). The toxin may also spread via the blood and damage tissues elsewhere in the body.

Finding the Test

During the epidemic, a tremendous effort was launched to find effective treatments and immunizations for the disease. One of the first findings was the diphtheria test. The test was developed by Béla Schick (1877-1967), a Hungarian pediatrician (children's doctor) who specialized in childhood diseases. The Schick test, as it was called, was based on the toxin-antitoxin research of German bacteriologist **Emil von Behring** (1854-1917). Behring's research revealed that the body will naturally develop its own protection from bacteria. These protective antitoxins or antibodies can neutralize (offset) the invading substances.

How the Test Works

The Schick test works by injecting a small amount of specially-prepared diphtheria toxin beneath the skin. If the person is susceptible to the disease, a red swollen rash appears around the injection area. A vaccine may then be used to protect the person from diphtheria.

The vaccine is a serum (a clear fluid) containing diphtheria toxoids. Toxoids are toxins from the disease that have been inactivated so they can't do any damage. The toxoid stimulates the production of diphtheria antibodies in the body to ward off the disease.

Used with the diphtheria vaccine, Schick's test dramatically reduced the occurrence of diphtheria worldwide. Until the 1920s, there were 150,000 to 200,000 cases of diphtheria in the United States each year. The number dropped to less than ten cases per year by the 1970s. Other scientists using Schick's approach developed similar tests for other dis-

eases. These diseases included measles, tuberculosis, pertussis, gonorrhea, and syphilis. The tests have saved thousands of lives.

Separation of Siamese twins

Siamese twins result when the zygote undergoes incomplete separation.

Siamese twins are identical twins who are physically joined together at some part of the body. Siamese twins result when the zygote (a fertilized ovum) undergoes incomplete separation.

The Most Famous Siamese Twins

In 1811 Chang and Eng Bunker were born in Siam (now known as Thailand). Joined at the chest by a ligament (soft tissue usually connecting two or more bones), the Bunkers toured the world as a side-show and circus attraction. They were billed as the "Siamese Twins" in reference to the country of their birth. Later on, this term was applied to all twins who were born joined together. The two brother lived to be 63 years of age and died within three hours of each other.

Separating Siamese Twins

Separating Siamese twins may be either a relatively easy or a difficult operation depending on how the pair are joined together. If the twins are joined by bones or ligaments, surgery is fairly easy. If the twins share a common organ, however, the surgery can be very difficult and it is rarely

Siamese twins Carmen and Rosa Taveras celebrate their first birthday. The girls were successfully separated during an operation in 1993.

Separation of Siamese twins

Month-old Siamese twin boys recuperate after being surgically separated in Taipei, Japan. The twins had been joined at the chest.

possible to save both lives. Generally, twins who are not separated have short life expectancies.

One of the modern tools used to help save the lives of Siamese twins is computer-aided surgery (CAS). Using this technique, doctors create computer tomography (CT) images of the twins. Using these high-resolution pictures, surgeons can plan the separation of the twins because it is easier to really see what they will find. It is also possible for doctors to view the areas to be worked on from a number of different angles. These different views let them better understand what work will be needed and how best to perform the operation.

One of the most unusual cases of separating siamese twins occurred in Israel in 1995. Twin girls were born who were joined at their urological and intestinal tracts. Only six sets of twins had ever been reported born this way—four sets survived. Almost immediately after their birth, the twins were separated in a three hour-long surgery. After two additional hours of reconstructive surgery on their colons, small intestines, and bladders the doctors rested. While the surgery was a success at the outset, the long term prognosis (outcome) is still unknown.

Sex hormones

Sex hormones are **steroids** (fat soluble compounds) that control sexual maturity and reproduction. These **hormones** are produced mainly by the endocrine glands. The endocrine glands in females are ovaries and those in males are testes. While both males and females have all types of hormones present in their bodies, females produce the majority of two types of hormones, estrogens and progesterone, while males produce mainly androgens such as testosterone. Most androgens produced by females are converted to estrogens and some androgens in males are also converted to estrogens. Sex hormones are synthesized from cholesterol (a fatty acid) and other compounds and secreted throughout a person's lifetime at different levels. Their production increases at puberty and normally decreases in old age.

Hormone Production

The production of hormones is a complex process. At puberty, the brain's hypothalamus gland produces increased amounts of gonadotropin-releasing hormone. This hormone stimulates the nearby pituitary gland to release two other hormones: follicle-stimulating hormone (FSH) and

luteinizing hormone (LH). Finally, these two hormones signal the sex glands (gonads) to produce the sex hormones.

Female Reproductive Cycle

Females produce three estrogens: estradiol, estriol, and estrone. These estrogens stimulate growth of the ovaries and begin preparing the uterus for pregnancy. Estrogens also control the body's secondary sex characteristics, including breast and pelvic development and the distribution of fat and muscle. Progesterone maintains uterine conditions during pregnancy. It also acts on the central nervous system in a way that isn't yet understood.

During the monthly reproductive cycle, FSH stimulates growth of an ovarian body called the graafian follicle. The follicle encloses the egg. LH aids in the rupture of the follicle, sending the egg to the fallopian tubes. LH also promotes growth of the corpus luteum (a yellow, progesterone-secreting mass of cells that forms from an ovarian follicle after the release of a mature egg) as the ovary prepares to release the egg into the uterus.

If no pregnancy occurs within 10-12 days, the corpus luteum withers and the uterus sheds the blood supply that was formed to nourish a fetus. This shedding of the uterine lining and blood supply is called menstruation (the period). The production of estrogens and progesterone drops dramatically, and the cycle begins again.

Male Reproduction

In males, LH stimulates the development of the testes. The testes produce the androgens testosterone and androsterone. When FSH activates the testes' sperm-forming cells, testosterone maintains the process of forming sperm. This is the ten-week process results in sperm constantly ready for release by ejaculation from the penis. The androgens also promote the secondary sex characteristics of muscle growth, lowered voice range, the Adam's apple, and increased body hair.

History

Sex hormones were studied intensively during the 1920s. Discovery of their steroid structure and relationship to other steroids was the key to their isolation and synthesis. The first breakthroughs came in 1929 with the female hormones. American biochemist Edward Doisy (1893-1986) isolated a crystalline form of estrone. Five years later, German biochemist Adolf Butenandt (1903-) and his colleagues isolated progesterone.

In 1931, American biochemists H. L. Fevold, F. L. Hisaw, and S. L. Leonard discovered luteinizing hormone (LH) and follicle-stimulating hormone (FSH). That same year, Butenandt and Kurt Tscherning isolated the

male hormones. In further male hormone developments, Swiss biochemist Leopold Ruzicka (1887-1976) soon determined the structure of testosterone. In 1934, Ruzicka partly synthesized androsterone from cholesterol, after proposing its structure. This was the first synthesis of a sex hormone and the first proof of the relationship between cholesterol and sex hormones.

Butenandt's group also showed that the sex hormones were related to cholesterol and bile acids, and in 1939 converted cholesterol into progesterone. For their work in demonstrating the structure of steroids, including the sex hormones, Ruzicka and Butenandt shared the 1939 Nobel Prize in chemistry.

Commercial Synthesis

Commercial synthesis came next. In the 1930s, Austrian chemists were synthesizing male and female hormones from soybean sterols (cholesterol-like substances). This process was expensive because it was hard to separate the sterols from each other. American chemist Percy Julian (1899-1975) discovered a much easier way to separate sterols, which permitted inexpensive synthesis of both progesterone and testosterone. American chemist Carl Djerassi (1923-) is also noted for synthesizing estrone and estradiol (estrogens) from plant materials.

Medical Uses of Hormones

In 1941 American surgeon Charles Huggins (1901-) was the first researcher to use **chemotherapy** (the chemical treatment of disease). Huggins treated prostate cancer with female sex hormones. For his work, he received the 1966 Nobel Prize in medicine. Today both male and female hormones are used to treat many kinds of cancer. Estrogen is also administered to treat menopause-related conditions and osteoporosis (the loss of bone calcium).

In addition to its use in the treatment of cancer, testosterone is administered by injection to treat men's sexual dysfunctions, such as impotence (inability to have an erection) and low sperm counts.

A synthetic progesterone called progestin was used in the first female oral contraceptive (birth control pill). The pill was developed by Americans **Gregory Pincus** (1903-1967), Min-Chueh Chang (1908-), and John Rock (1890-1984). Today a variety of pills containing varying amounts of progesterone and estrogen are available by prescription.

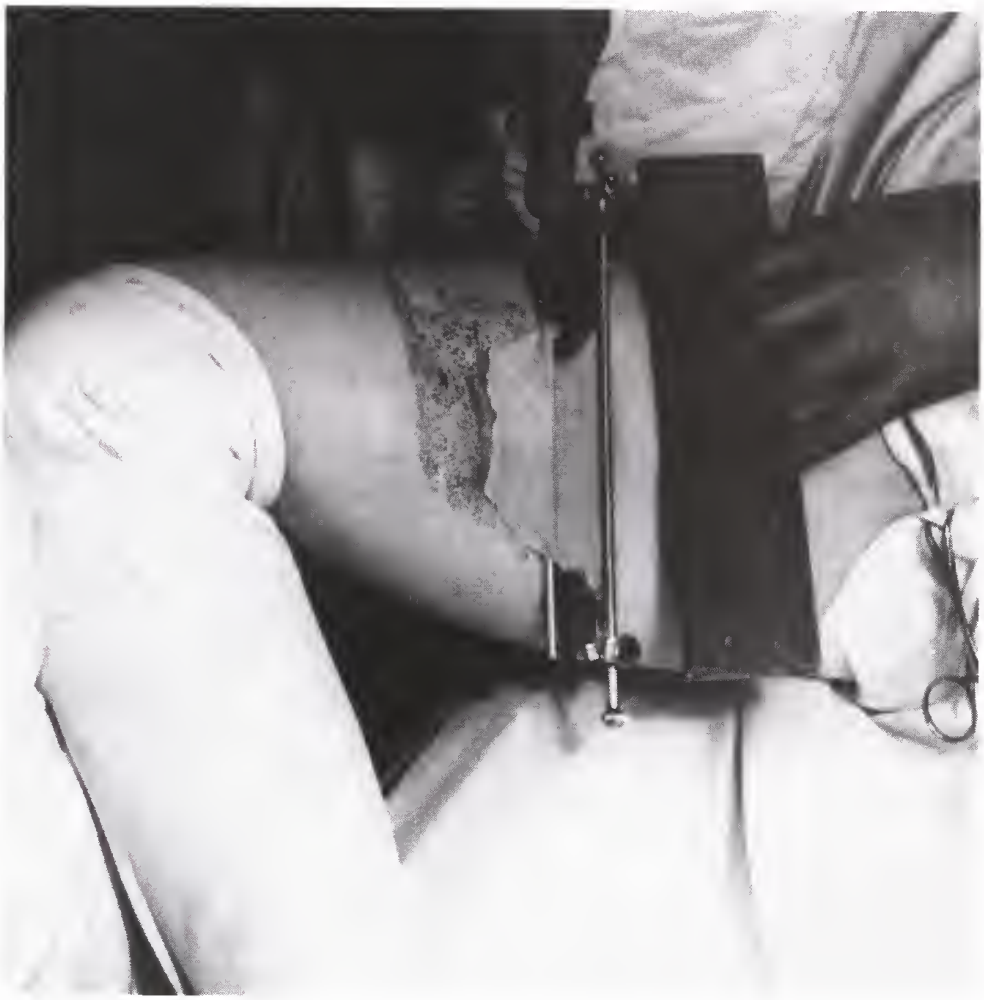
[*See also* **Birth control; Hormone; Pincus, Gregory; Steroids**]

Skin grafts

Skin grafts have been performed for a long time. In the sixth century B.C., doctors in India were successfully performing skin grafts. The practice apparently was not used outside of that area of the world again until many centuries later.

Tagliacozzi's Graft

In the sixteenth century, Italian surgeon Gaspare Tagliacozzi revived the old procedure. He attached a skin flap from the forearm of a patient to the nose. Since he used living tissue, the flap was still attached to the patient's arm when the attachment was made. After the tissue started to grow on the nose a few weeks later, Tagliacozzi severed the flap from the arm. Tagliacozzi did not attempt to perform skin grafts using skin from other people. He felt that body would naturally reject foreign body tissue.



Skin is harvested for a graft. Today, medicines like Imuran have increased the likelihood of successful skin graft surgery.

In fact, rejection of tissue is the greatest problem with grafts or **transplants** of any type.

Imuran

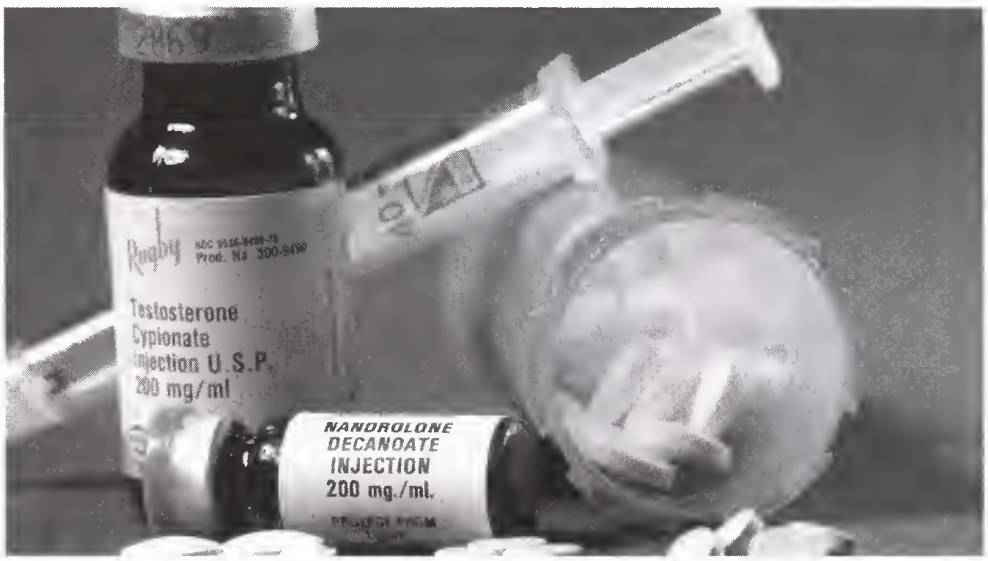
Using drugs like Imuran (or azathioprine; developed in 1962) increased the likelihood of success with grafts. In 1963 **steroids** were used in conjunction with Imuran during surgery. The results were even more improved. Today, the use of steroids with immunosuppressants is considered normal treatment. An immunosuppressant suppresses the body's natural immune response to an antigen.

Steroids

People usually think of steroids as drugs that athletes take to build their bodies more quickly. Steroids are more than that. They form an organic compound group that include sterols, **D vitamins,** bile acids, some **hormones,** saponins, glucosides (organic compounds that produce sugar) of **digitalis,** and some carcinogenic (cancer-causing) substances. These compounds may come from a number of different substances and have a variety of functions.

Cholesterol

Sterols, for example, are related to fats and are found in either plants or animals. An common example of a sterol is cholesterol. Cholesterol is found in almost all body tissues, particularly the nervous system, liver, kid-



Steroids. Steroids form an organic compound group that includes sterols, D vitamins, bile acids, and some hormones

neys and skin. It forms part of cell membranes and is synthesized in the liver and other organs. The body uses cholesterol to produce other steroids. For several decades, doctors have associated cholesterol with the build-up of damaging plaque in the arteries.

Other Steroid Group Members

Saponins are found in the roots of some plants. They can be very dangerous since they can destroy red blood cells. The steroid digitalis is a plant product used to stimulate the heart. It is a dangerous drug that must be administered with care because an overdose can be fatal. Sex hormones that control sexual maturity and reproduction are also steroids. Sex hormones include androgens for male functions and estrogens and progesterone for female functions.

[*See also* **Sex hormones; Vitamin**]

Stethoscope

The stethoscope is an instrument for listening to sounds produced by organs in the human body, including the heart and lungs. One end of the stethoscope is placed against the body, and the other end is placed in or at the ear, a method called direct auscultation. The sounds are then interpreted by an experienced listener.

Auenbrugger Invents Percussion

In the late 1700s Leopold Auenbrugger (1722-1809), a Viennese doctor, developed a technique called percussion. Auenbrugger tapped on his patient's chest and then analyzed the different sounds he heard. He published his findings in a pamphlet in 1761. The pamphlet was ignored by the medical profession until the early 1800s. At that time, Jean Nicholas Covisart (1755-1821) adopted Auenbrugger's percussion technique. Covisart translated Auenbrugger's pamphlet into French and encouraged Rene Theophile Laennec (1781-1826), one of his students, to study acoustic diagnosis.

Designing the Stethoscope

Laennec invented the stethoscope in 1816 during an examination of a young woman with a heart affliction. Laennec was unable to put his ear to the woman's chest to evaluate her condition. This was both because the patient was a very large woman and because moral standards of the day

considered such an examination to be immodest (indecent). In a burst of inspiration, Laennec rolled a sheaf of paper tightly into a tube. He placed one end of the tube over the patient's heart and listened from the other end. The doctor later wrote, "I was both surprised and gratified at being able to hear the beating of the heart with much greater clarity and distinctness than I had ever done before by direct application of my ear."

Laennec made a later stethoscope from a wooden tube. In 1819 Laennec wrote a book describing his instrument and the diagnoses to be made with it. To help promote the book, the publisher gave a stethoscope with each book purchase.

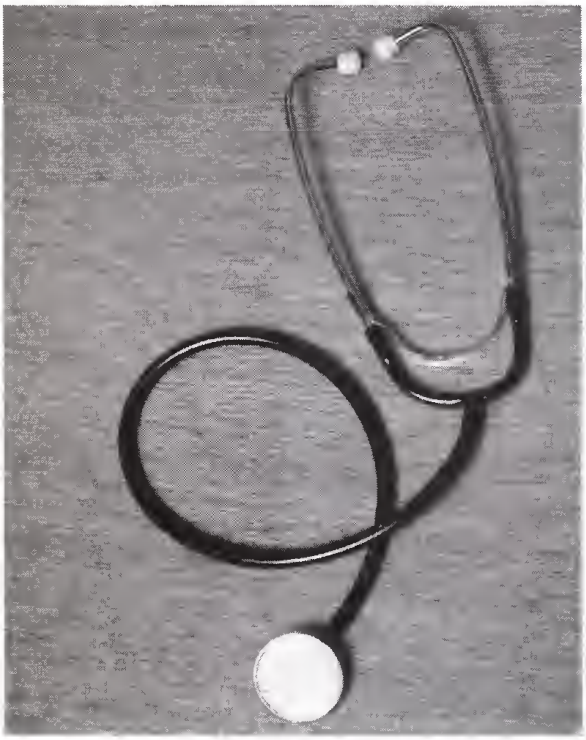
Skoda Promotes the Stethoscope

Austrian doctor Joseph Skoda (1805-1881) promoted the use of the stethoscope. He was very instrumental in popularizing its use for diagnostic purposes. Various improvements were made to the device over the years, including the use of pliable (flexible) tubing, introduced in 1850. In 1852 American doctor George P. Cammann developed a binaural stethoscope, a stethoscope with an earpiece for each ear.

A modern stethoscope. The stethoscope is an instrument for listening to sounds produced by organs in the human body, including the heart and lungs. One end of the stethoscope is placed against the body and the other end is placed in or at the ear.

The Electronic Stethoscope

The next major development in stethoscope design came 100 years later, when the electronic stethoscope appeared in 1980. One application of an electronic stethoscope is the fetal monitor, which is used to listen to a unborn baby's heart rate. With the "external" monitor, the heart rate is heard through belts placed around the mother's abdomen (stomach). With the "internal" monitor, the heart rate is heard through a wire that is attached to the baby's scalp.



The advantage of electronic monitoring of the heart rate is that the monitor provides continuous listening and can pick up uncommon patterns, then can sound an alert so that medical personnel can take immediate action. That action is almost always to deliver the baby by **Cesarean section** (abdominal surgery), then to guard against oxygen starvation, which may occur with a faulty heartbeat and ultimately result in brain damage.

Electronic stethoscopes are also being studied for their usefulness in areas where the

patient is remote (distant) from the physician, a form of diagnosis called telediagnosis. The quality of the information obtained from the electronic stethoscope compared very well with direct, or conventional, auscultation. The method brought the information, or data, to the physician using a modem and a standard telephone line.

When pitted against direct auscultation, the electronic stethoscope missed some faint heart murmurs, so the standard stethoscope—-which doesn't need electricity to work—-remains valuable and widely used. Its portability, low cost, and ready availability make the stethoscope an ideal basic tool.

Streptomycin

The discovery of streptomycin by microbiologist Selman Abraham Waksman (1888-1973; winner of the 1952 Nobel Prize in medicine) occurred in the mid-1940s. The discovery of this effective and safe **antibiotic** led to the taming of tuberculosis, or "TB." Streptomycin has also been found effective in treating several other infectious diseases.

The Search Begins with Soil Microbes

Prior to his most exciting discovery, Waksman, a Russian-born American microbiologist, had been engaged in a study of soil microbes for a number of years. One of his students, French-born René Jules Dubos (1901-1981), was searching for antibacterial substances in soil. In 1939 Dubos discovered the first antibiotic drug, gramicidin. Although it fought pneumococcus, staphylococcus, and streptococcus bacteria, it was too toxic (poisonous) for use in humans.

Waksman was inspired by Dubos's discovery. With the support of the Merck pharmaceutical company, he turned his attention to antibacterial substances found in soil. In 1941, he dubbed these substances "antibiotics." By 1958 he had discovered eighteen such drugs. Of these, streptomycin was the most important. Waksman isolated the antibiotic in 1943 and found it to be active against gram-negative bacteria. Eventually, streptomycin proved to be effective at fighting the tubercle bacillus. Because the tubercle bacillus can enclose itself in nodules in the body, it can remain dormant for years. When TB becomes active, it can strike any part of the body, but normally attacks the lungs. At the time Waksman developed streptomycin, the only treatments for TB were prolonged bed rest and nutritious food.

A man filters and subdivides streptomycin at the New Sterile Techniques Plant owned by Merck & Company.

Testing the Drug

Pathologist William Hugh Feldman (1917-) and bacteriologist H. Corwin Hinshaw (1902-) conducted the first clinical trials of streptomycin against tuberculosis. Feldman and Hinshaw first tested streptomycin on guinea pigs infected with tuberculosis. They found the drug to be nontoxic as well as highly effective. By 1945 Feldman and Hinshaw had conducted their first tests of streptomycin in human tuberculosis patients. The drug arrested the bacteria and reversed the disease. Feldman and Hinshaw's studies showed that the antibiotic was effective against a number of different forms of tuberculosis. These included TB of the skin, bones, lung, meninges, joints, and genito-urinary tract. The side effects caused by the drug included impairment of the sense of balance and deafness. These side effects proved to be temporary and could be minimized by controlling the dosage of the drug.

The Merck company agreed to turn over the rights for streptomycin to Rutgers University, which in turn licensed companies for production. In the late 1940s eight pharmaceutical companies began mass producing streptomycin. An estimated $1 million worth of the drug was provided for the largest clinical study of a drug ever undertaken, a study involving several thousand tuberculosis patients.

Other Uses for Streptomycin

Not only was streptomycin found to be effective and safe in treating tuberculosis, but eventually it was found to be active against 70 different types of bacteria which do not respond to **penicillin** including infections of the abdomen, urinary tract, pelvis, and meninges. Clinicians soon found additional drugs capable of destroying the TB bacillus. No less than 11 such drugs were isolated, providing physicians with a potent arsenal in the battle against TB. Using a combination of two or more drugs, doctors could strike at the stubborn microbes with great effectiveness. By the 1970s, the disease could be successfully treated in nearly all cases.

Tuberculosis continues to be the most deadly infectious disease in the world. It attacks thousands of people in regions where adequate medical treatment is not available. Recently, concern about the return of TB has been voiced in the United States. Many victims of immune deficiency diseases such as AIDS have been infected with TB. In addition, physicians are concerned about the large number of TB victims who abandon their medical treatment before it is complete. Despite the effectiveness of drugs like streptomycin, acts like this keeps the disease alive and increase the chance of it spreading to others.

Strychnine

The plant source of alkaloid strychnine was discovered in 1818. This discovery was made by French chemists Joseph-Bienaimé Caventou (1795-1877) and Pierre-Joseph Pelletier. Strychnine comes from the seeds of the nux vomica tree that grows in India. Pelletier was eventually successful in developing a means of extracting strychnine from this source. While strychnine was just one of many plant alkaloids isolated by Caventou and Pelletier, it is unique because of its complex structure of interlocking rings.

Strychnine Medicine

Although strychnine is a poison, it has been used in the past as a medicine. Strychnine was once prescribed as a remedy for heart and respiratory complaints and as a stimulant (or body "upper"). It is no longer used today because the size of an effective dose would be toxic.

Synthesizing Strychnine

American chemist Robert Burns Woodward (1917-1979; winner of the 1965 Nobel Prize in chemistry) was successful in synthesizing (blending artificially) numerous complex organic compounds. For example, in 1944 he worked with William von Eggers Doering to synthesize **quinine,** a malaria treatment.

Woodward discovered the structure of strychnine in 1949. He began manufacturing the drug in 1954 using a complex manufacturing process. This process involved several stages where careful planning was needed to control the internal design of the compounds. In the synthesis of most compounds, the important factor is that the drugs become less expensive and more readily available. The simpler the manufacturing process, the better the chemical companies like it. In this case however, Woodward did something different. He synthesized a very complex molecule using a complex process from simple chemicals. This was a major manufacturing innovation and Woodward's findings proved to chemists that this type of synthesis was possible.

Subzonal injection

Subzonal injection is a method of **in vitro fertilization.** In this procedure, a drop of fluid containing sperm is placed under a **microscope.** Then five or ten of the healthiest looking sperm are scooped up into a threadlike,

hollow glass needle. The needle is used to penetrate the shell of the ovum (or egg), creating an entry point for the sperm. The egg itself, however, is not touched or penetrated.

Subzonal injection was developed in the 1990s and has been a fairly successful procedure. It does require several healthy sperm and at least one of the sperm must penetrate the egg on its own. To be successful, only one sperm can fertilize an egg. If more than a single sperm fertilizes the egg, the egg will not develop into a normal embryo.

Sulfonamide drugs

The sulfonamides, also known as sulfa drugs, halt the growth of bacteria. Their discovery paved the way for cheap and effective treatment of often fatal infections, including certain types of pneumonia.

Chemical Dyes Yield Medical Results

Before 1932, no synthetic (manufactured) chemicals existed for the treatment of bacterial infections. A new era in medicine was ushered in by German chemist Gerhard Domagk (1895-1964). It was Domagk who began a search for chemical substances to kill bacteria within the human body.

Domagk worked for I. G. Farben, a German chemical company. At Farben he served as director of the Laboratory for Experimental Pathology and Bacteriology. Domagk examined the properties of dyes synthesized by his colleagues, testing them for use as drugs. He found that dyes containing a sulfonamide group seemed to bind tightly to wool fabrics. Because both wool and bacteria are proteins, Domagk was interested. He reasoned that such dyes might fasten themselves to bacteria, inhibiting or killing them. In 1932 he discovered that a dye called Prontosil controlled streptococcal infections (strep) in mice. Prontosil also controlled staphylococcal infections in rabbits with no harm to the animals.

Testing the Drug

Domagk's employer began to test Prontosil on infections in humans. Domagk himself had an unexpected opportunity to test the dye's effectiveness close to home. The prick of a needle in his lab accidentally infected his young daughter with strep bacteria. While still uncertain of what the outcome would be, Domagk gave her Prontosil. She made a rapid recovery. It was suddenly clear that Prontosil had the ability to control

streptococcus infections in humans. In 1936 Prontosil was given to the son of Franklin Delano Roosevelt (president of the United States from 1933-1945). Franklin D. Roosevelt, Jr., initially thought to be dying, then rapidly recovered from a streptococcal infection.

Improving the Drug

In 1936 French chemists Jacques and Thérèse Trefouel, working with Daniele Bovet (1907-1922), separated sulfanilamide from Prontosil. Sulfanilamide is the parent sulfa compound. The researchers found that sulfanilamide, and not the dye itself, killed bacteria. Since then, more than 5,000 sulfa drugs have been prepared and tested. Repeated use of sulfa drugs does, however, cause bacteria to become resistant. Because of this, fewer than 20 sulfa drugs have been found to continually to kill the same bacteria strains.

The introduction of **antibiotics** like **penicillin has** decreased the need for sulfa drugs. However, sulfa drugs are still useful in the treatment of infections. Streptococcal infections, urinary tract infections, and ulcerative colitis (a digestive track disorder) are all treatable with sulfa drugs. In addition, sulfanilamide is still commonly used in veterinary medicine.

Surgical instruments

Surgery has been performed since ancient times. The earliest recorded surgical operations were circumcision and trepanation. (Circumcision is the removal of the foreskin of the penis. Trepanation involves making a hole in the skull to relieve pressure and/or release spirits.) The earliest instruments used in these procedures were flint or obsidian (shiny stone) knives and saws. Stone Age skulls from around the world have been found with holes in them from trepanning. Primitive people also used knives to cut off fingers damaged in accidents.

The earliest instruments used in surgery were flint or obsidian knives and saws.

Ancient Surgery

Ancient Mesopotamian (an area in southern Asia between the Tigris and Euphrates rivers) cultures practiced surgery to some degree. Small copper Sumerian (present-day southern Iraq) knives of about 3000 B.C. are believed to be surgical instruments. The Babylonian Code of Hammurabi of about 1700 B.C. mentions bronze lancets (sharp-pointed two-edged instruments used to make small incisions). Because the Code provided harsh penalties for poor medical treatment outcomes, surgery was prac-

ticed only sparingly. Ancient Chinese and Japanese cultures were opposed to cutting into bodies, so surgical instruments were not used much.

By contrast, the ancient Egyptians recorded surgical procedures as early as 2500 B.C. Egyptians fashioned sharper instruments with a new metal, copper. They designed special tools to remove the brain from the skull when preparing bodies for mummification.

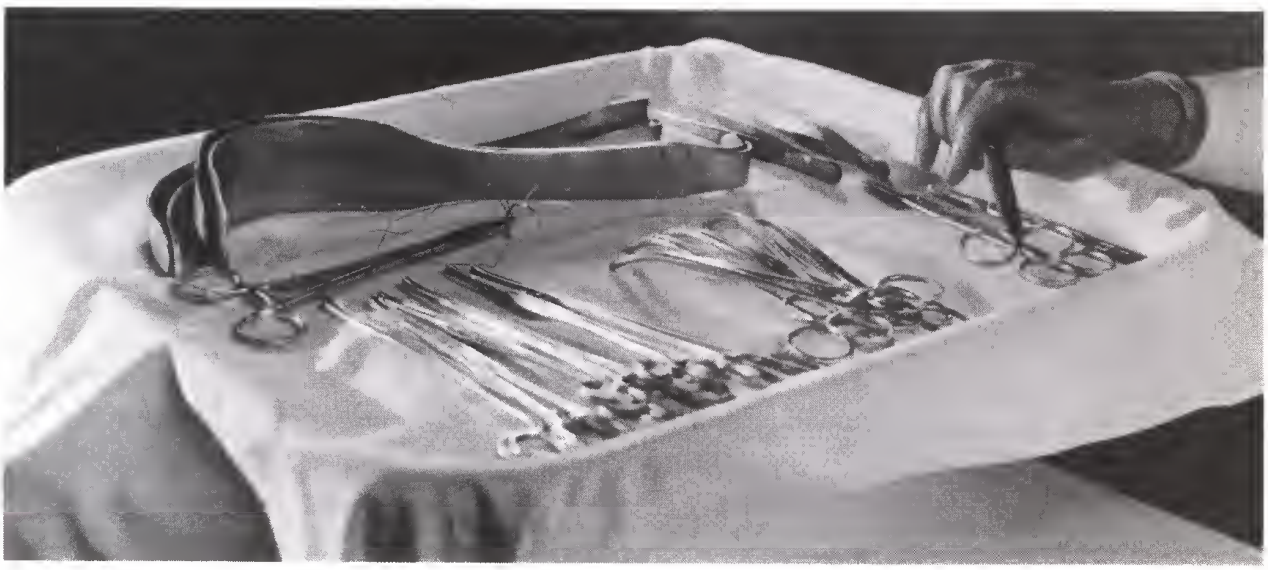
Hindus Excel at Surgery

The ancient Hindus of India excelled at surgery. The great surgical textbook, *Sushruta Samhita,* probably dates back to the last centuries B.C. This work described 20 sharp and 101 blunt surgical instruments. These instruments included forceps, pincers, trocars (sharp-pointed instruments fitted with a small tube), and cauteries (irons to heat and sear tissue). Most of these surgical tools were made of steel. The ancient Hindus also used lancets to carry out **cataract surgery,** scalpels to restore amputated noses via plastic surgery, and sharp knives to remove bladder stones. At about the same time, ancient Peruvians were performing trepanation. They left behind various surgical instruments, including scalpels and chisels made of obsidian.

Greek and Roman Surgery

The Greeks practiced surgery mostly on external parts of the body. They usually used forceps, knives, and probes. Bronze Roman surgical instruments found at Pompeii include a scalpel with a steel blade, spring and scissor forceps, a sharp hook, and shears. In the first century A.D., Cel-

A tray of modern surgical instruments. The ancient Hindus used lancets to carry out cataract surgery, scalpels to restore amputated noses via plastic surgery, and sharp knives to remove bladder stones.



cus described the use of ligatures. Ligatures are used to tie off blood vessels and reduce bleeding during operations. **Galen** (A.D. 130-200) gave detailed and sensible instructions on the use of surgical instruments.

After ancient times, medical knowledge declined, and surgeons fell to a lowly status. In the absence of knowledge about antiseptics, surgery was highly risky. As a result, only the simplest and most urgent operations (such as **amputations**) using the most straightforward instruments were performed. A few physicians sought to spread knowledge of surgical procedures by publishing texts that illustrated surgical instruments. Most important among these men was the great French surgeon **Ambroise Paré** (1517-1590). Paré revived use of ligature and invented many surgical procedures and instruments. His inventions included the "crow's beak" to hold blood vessels while tying them off. Paré also perfected an instrument for cataract removal.

The Modern Era of Surgery

The era of modern surgery began with the introduction of both **anesthesia** and antiseptics/**antisepsis** in the mid-1800s. In 1878 **Louis Pasteur** (1822-1895) first suggested sterilizing surgical instruments. American doctor William Halsted (1852-1922) introduced sterile rubber gloves in the 1890s. The 1895 discovery of **X-rays** gave surgeons an invaluable diagnostic tool.

Great Refinements

Great refinements in surgery were made possible by the introduction of the operating microscope (thus allowing microsurgery) in the mid-twentieth century. The development of **laser surgery** in the 1970s was another great advancement. Both of these instruments permit operations on very delicate body structures. The increasingly sophisticated technology of the twentieth century makes ever-more-precise surgical tools possible. Among the newest devices are voice-activated operating microscopes and robotic surgical hands.

Syphilis test

Syphilis was once a disease of epidemic proportions. Today, it is effectively treated with **penicillin** and other **antibiotics.** Because there is no known immunization to protect against contracting syphilis, accurate testing has become a key determinant for quick and successful treatment.

Discovery of the Bacteria

In 1903 Russian biologist Elie Metchnikoff (1845-1916) and French scientist Pierre-Paul-Emile Roux demonstrated that syphilis could be transmitted to monkeys. With this capability, the disease could be studied in the laboratory. Two years later, German zoologist Fritz Schaudinn and his assistant Erich Hoffmann isolated the bacterium that causes syphilis. Schaudinn and Hoffmann showed it to be a spiral-shaped spirochete called Treponema pallidum.

Salvarsan

In 1904 German researcher **Paul Ehrlich** (1854-1915) and Japanese bacteriologist Sahachiro Hata began looking for a safe, effective treatment for syphilis. They tested hundreds of derivatives of atoxyl, eventually discovering one that worked. Ehrlich called the derivative "Salvarsan." Following trials of the substance on humans, Ehrlich and Hata announced in 1911 that the drug was an effective cure for syphilis. The drug attacked the bacteria without harming healthy cells.

Wassermann Test

The first effective test for syphilis was developed in 1906 by German physician and bacteriologist August von Wassermann (1866-1925). Wassermann was influenced by Ehrlich's work. Wassermann's exam consisted of testing a patient's blood sample for the syphilis bacterium antibody. If antibodies were present, the test was positive. If the antibodies disappeared after treatment, the test was negative. The Wassermann test proved successful in diagnosing syphilis in 95 percent of cases.

Kahn Test

Unfortunately, the Wassermann test required a two-day incubation period. Reuben Leon Kahn (1887-1979), a Russian-born American immunologist, developed a faster and simpler syphilis test in 1923. This modified test used an extract from beef heart to detect syphilis antibodies. More sensitive than the Wassermann test, the Kahn test could be completed in a matter of minutes. The Kahn tests, however, could also be inaccurate. It could show false positive or false negative reports.

Davies-Hinton Test

Another effective syphilis test was developed by William A. Hinton (1883-1959). Hinton was an African-American physician who became a leading expert on venereal disease. Hinton worked out of Harvard Medical School, collaborating with J. A. V. Davies on the Davies-Hinton test.

Syphilis

Syphilis is a serious disease transmitted through sexual activity. Although modern treatments can control the disease, the number of people suffering from syphilis remains high. It is a public health concern around the world.

Syphilis can be cured through doses of penicillin, yet many people remain untreated. The first stage appears between one and eight weeks after infection occurs. The symptom is a small, hard, painless swelling, called a primary chancre (pronounced "shanker"). The sore usually heals in one to five weeks. However, during this period, disease bacteria circulate throughout the body via the bloodstream.

The second stage appears about six weeks after the sore disappears. Symptoms include a general feeling of being ill, fever, headache, and a loss of appetite. Glands may swell in the groin or neck, and a skin rash may develop. This second stage can last two to six weeks.

The third stage is called latent or late syphilis. It can last for years. While no symptoms may be present for some time, a special blood test will show the presence of the disease. During this stage, the disease will eventually flare up without warning. Syphilis affects both the brain and heart. At this point, the disease is no longer treatable. Symptoms of third stage syphilis include blindness, sterility, and insanity.

VDRL Test

Several other syphilis tests have been developed. One of most widely used tests today is the VDRL test, designed by the Venereal Disease Research Laboratory. Other diagnostic tools include a fluorescent antibody test to reveal the syphilis bacterium.

Syringe

The syringe is a pump-like device used to inject or remove liquids by suction. It consists of a tube that is tapered at one end and has a plunger at the other end. When the plunger is pulled back, it creates suction. When pushed forward it forces out fluid. The syringe may be used for intravenous

(into the vein), intramuscular (into the muscle), or intradermal (between skin layers) injections to administer drugs or vaccines. It is commonly used for hypodermic or subcutaneous (beneath the skin)injections.

Inventing the Syringe

The idea of the syringe is thought to have originated in fifteenth-century Italy, although it took several centuries for the device to be developed. In 1657, experiments were conducted on syringe-like devices by Englishmen Christopher Wren (1632-1723; also famous architect) and Robert Boyle. French physician Dominique Anel is usually credited with the invention of the kind of syringe used today. Anel was a surgeon in the army of French King Louis XIV (1638-1715). Anel created his instrument to clean wounds with suction.

The first true hypodermic syringe was created by French physician Charles Pravaz in 1853. Made entirely of silver, this syringe held one cubic centimeter of liquid. Around the same time, Scotsman Alexander Wood devised a subcutaneous injection method. This allowed physicians to administer intravenous **anesthesia** for the first time. An Englishman named Fergusson used a syringe made partially of glass. This important change permitted visual monitoring of injections. In 1869 the all-glass syringe was developed by a man named Luer in France. The ease with which this syringe could be sterilized further reduced the risk of infection.

Disposable Syringes

Today, increased public awareness about transferring diseases by using shared hypodermic needles has led to the widespread use of dispos-

Modern syringes. The first true hypodermic syringe was created by French physician Charles Pravaz in 1853. Made entirely of silver, this syringe held one cubic centimeter of liquid.

able syringes. Diseases such as acquired immune deficiency syndrome (AIDS) caused by the communicable human immunodeficiency virus (HIV) have increased the use of these throw-away syringes.

Because sharing unsanitary needles containing traces of HIV-infected blood have made drug users among the most common victims of AIDS, in some cities disposable syringes have been distributed free to users of illegal, injectable drugs. This has been done as a public health measure in an effort to reduce the sharing of unsanitary needles and thus decrease the transmission of HIV.

Thermometer

In the earliest days of the medical profession, no device existed to measure a patient's body temperature. Evaluating a patients' body temperature depended totally on the doctor's personal methods of observation. It was not until the late sixteenth century that scientists devised an instrument able to detect changes in air temperature. It was many years later that a medical thermometer was constructed.

Galileo's Thermometer

The first thermometers were created to measure changes in air temperature. The most famous of these was invented by Galileo (1564-1642) in 1592. Called an air-thermoscope (or air thermometer), it consisted of a long glass tube with a wide bulb at one end. When the tube was first heated the air inside expanded and some of it was naturally expelled. While still warm, the open end of the tube was placed into a flask of water. As the tube cooled, the warm air contracted, drawing water into the tube. Once the tube-and-water system reached a state of balance, any change in air temperature would cause the level of the water within the tube to rise or fall.

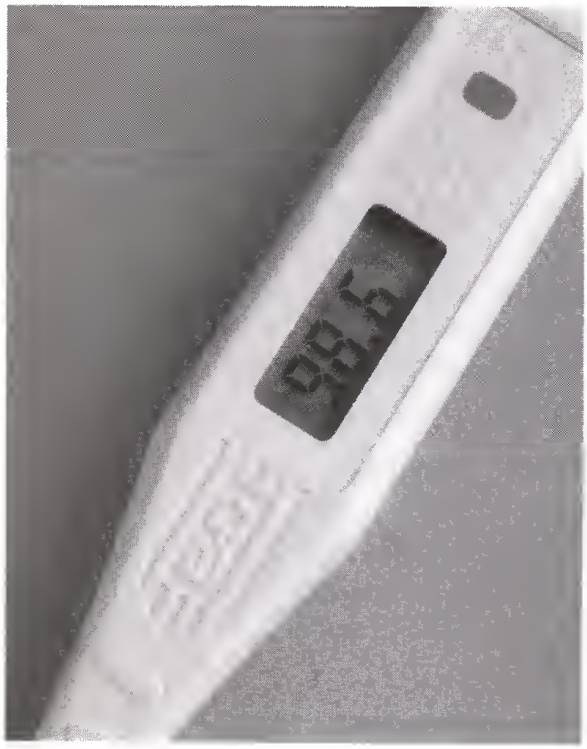
There were two major hindrances to the acceptance of the air-thermoscope. First, the varying sizes of the tubes made it very difficult to graduate the device and therefore establish a degree scale. Second, it was soon discovered that the air-thermoscope was unreliable. It gave widely varying readings for apparently identical temperatures.

In the 1660s it was realized that the open-ended system would react to air pressure as well as temperature. This meant that the instrument per-

formed as a barometer as well as an air thermometer. This realization came several years after a solution was found in 1654 by Duke Ferdinand II of Tuscany. The duke constructed a sealed liquid-in-glass thermometer that did not vary with changes in air pressure. Coupling this new thermometer with graduations devised in 1612 by Italian doctor Santorio Santorre, the device was complete.

Perfecting the Design

European scientists quickly began working to perfect the design of the thermometer. One of the issues addressed was the need for an instrument that could travel by sea. This was because ordinary liquid thermometers were rendered unreliable by a ship's rocking motions. In 1695 French physicist Guillaume Amontons designed a thermometer composed of a tube filled with compressed air and capped with a layer of mercury. As the temperature increased the air would expand, causing the mercury level to rise. Conversely, as the temperature decreased, the mercury would fall. Another Frenchman, René de Réaumur (1683-1757), sought to improve upon Amontons's design by replacing the air-and-mercury system with a mixture of alcohol and water. Reaumur's thermometer was remarkable in that he devised an 80-degree temperature scale based upon the freezing and boiling points of water. These were to be the same points that would become the basis for the more widely accepted scales of Celsius and Fahrenheit.



A digital thermometer.

Standardized Temperature

At the turn of the eighteenth century the most important issue for scientists and instrument makers was the lack of a standard temperature scale. Because the level of glass-blowing technology was too poor to make identical thermometer tubes, every scientist's temperature scale was different. In 1717 a Dutch instrument maker Daniel Fahrenheit introduced a line of mercury-filled thermometers of nearly identical proportions. His use of mercury in very thin tubes allowed him to graduate the scale into many degrees. He used the boiling (212 degrees) and freezing (32 degrees) points of water as reference points. Fahrenheit developed the first scale to be accepted as a worldwide standard.

The Fahrenheit scale enjoyed global popularity for many years, until the introduction of

the 100-degree scale by Anders Celsius in 1746. Several scientists had attempted to popularize a 100-point scale, but Celsius was the first to also utilize water's freezing and boiling points as the 0- and 100-degree marks. Originally, Celsius placed the freezing point at 100 degrees and the boiling point at 0 degrees. This was reversed in 1747, at which time the centigrade (meaning "500 steps") scale began to increase in popularity. In 1946 the Celsius scale was adopted by most of the world as the official temperature scale.

The Medical Thermometer

Probably the most familiar thermometer is that found in a doctor's office, or the "clinical thermometer." The clinical thermometer was invented in 1866 by Sir Thomas Clifford Allbutt, an English physician. The important features of this thermometer were that it was relatively short, usually no longer than six inches, and it responded quickly to the patient's temperature. Previous instruments required nearly 20 minutes to get an accurate reading, while Allbutt's thermometer could reach equilibrium in less than five minutes. This made it easier for doctors to follow the course of a fever, since temperatures could be taken more quickly and more often.

Modern thermometers come in many different varieties. New thermometers are being designed that can read a patient's temperature using infrared technology. These devices can determine a person's temperature in about one minute, and take the reading from inside the ear, rather than the mouth.

Thiamine

Like all the water-soluble B vitamins, thiamine functions as a coenzyme. Thiamine works primarily in the metabolism (processing) of carbohydrates, fats and proteins. It also helps to produce ribose, an important sugar needed by all body cells for the production of nucleic acids.

Thiamine is neither synthesized (blended or created artificially) by the body's intestinal bacteria nor stored in fat tissues. Because the body neither produces nor stores thiamine, a daily dietary source is needed. Without such a source, both humans and most animals soon develop some form of deficiency disease. In humans, the disease is called beriberi. Beriberi is a serious and disabling disease characterized by polyneuritis (an inflammation of nerves in the arms and legs.) It was the search for a cure for beriberi that led to the discovery of thiamine.

Beriberi Research

In the 1880s most physicians were certain that beriberi was caused by some sort of toxic (poisonous) bacteria. The disease was particularly widespread in Far Eastern countries where rice was a dietary staple. Because of this, the bacteria was suspected to be in rice. In 1886 a commission was sent to the Dutch East Indies (now Indonesia) to try and locate the causative organism. The commission failed to find the organism, but one of its members, **Christiaan Eijkman** (1858-1930) stayed behind to continue his experiments.

Between 1890 and 1897 Eijkman began reporting that chickens fed a diet high in polished rice developed symptoms similar to those of his beriberi patients. Even more important, Eijkman reported that adding rice hulls to the diet quickly effected a cure. A colleague named Gerrit Grijns found that other foods—including green peas and meat—could also prevent beriberi. In 1901 Grijns correctly deduced that beriberi was not the result of a bacteria based on his experiments which proved that certain natural foodstuffs contained an anti-beriberi factor.

Roughly a decade later Casimir Funk, a Polish-born biochemist, was inspired by reading the reports of Grijns and Eijkman. Funk began searching for the elusive anti-beriberi factor in rice hulls. He managed to isolate an active substance and was briefly elated. Unfortunately, the substance (which later proved to be **niacin**) had only minimal effect on beriberi. Funk discarded it and went on with his research.

In 1926 two other biochemists isolated a crystalline material that could actually cure polyneuritis in birds. The discovery was made by P. Jansen and W.P. Donath, working in the same laboratory in the Dutch East Indies originally used by Eijkman and Grijns. The two researchers called the substance they found aneurine. Too little of the substance could be isolated, however, to make identification certain.

A Rare Substance

In the 1930s scientists made important discoveries that would allow them to synthesize the substance. In 1932 German chemist Adolf Windaus (1876-1959) was able to isolate a sulfur atom in a molecule of another substance. This proved to be a crucial step in determining the structure of the elusive compound. In 1934 American chemist Robert Runnels Williams (1886-1965), isolated one-third of an ounce of the active crystalline material from almost a ton of rice hulls. His procedure used highly advanced laboratory techniques, but was too expensive to be used for mass production. Because the v**itamin** proved to contain a sulfur molecule (of the thio

group) and an amine, the substance was named thiamine. Two years later, Williams and his colleagues successfully synthesized the substance.

Today thiamine is a regular component of many multivitamins and continues its role of preventing this ancient disease.

Thyroxine

Thyroxine is the principal **hormone** produced by the thyroid gland. It promotes protein synthesis (blending) and growth, and also helps regulate the body's metabolism.

Thyroid Stimulating Hormones

Thyroxine is produced by the thyroid gland in a very complex way. When the blood's thyroxine level is low, the brain's hypothalamus (the part of the brain that regulates body functions) produces a thyrotropin-releasing hormone. This stimulates the pituitary gland to produce thyrotropin. Thyrotropin is a thyroid-stimulating hormone (TSH) that excites the thyroid gland. When the blood's thyroxine level is high, the hypothalamus releases a hormone that inhibits TSH production.

Hyperthyroidism

Hyperthyroidism is a condition caused by an overactive thyroid. The syndrome can cause weight loss, nervousness, and protruding eyes. Called Graves's disease, it was first identified by Irish physician Robert James Graves (1796-1853).

Treating Underactive Glands

German chemist Eugen Baumann (1846-1896) was the first researcher to treat underactive thyroids using extracts made from animal thyroid glands. In 1914 American biochemist Edward Kendall isolated and used the crystalline form of the hormone which was later named thyroxine. In 1926 the British chemist C. R. Harington (1897-1972) determined thyroxine's exact structure and synthesized it out of materials in a laboratory.

Treating Overactive Glands

Today, overactive glands can be treated with medication, removed surgically, or destroyed by radiation. When the gland is removed or destroyed the patient must always take thyroid hormones as replacement therapy. Hormone therapy is also used for underactive glands.

The first widely-used test to measure peoples' thyroid levels was developed in the 1930s by American biochemist Evelyn B. Man (1904-1992). Called the protein-bound **iodine** test, it soon showed that many "demented" patients in mental hospitals (those having deteriorated mental capabilities) actually had underactive thyroid glands. Treatments with thyroxine helped many of these patients regain normal mental abilities.

Doctors now routinely evaluate an infants' thyroid function by testing blood from newborn babies' umbilical cords. This allows correction of any thyroid gland problem before mental or physical damage occurs.

Toothbrush and toothpaste

Early Brushes

The earliest toothbrushes were simply small sticks mashed at one end to increase their cleaning surface. Ancient Roman aristocrats employed special slaves to clean their teeth. Brushing the teeth was part of some ancient religious observances.

The bristle brush was probably invented by the Chinese and brought to Europe during the seventeenth century. French dentists, who were then the most advanced in Europe, advocated the use of toothbrushes in the seventeenth and early eighteenth centuries. Dentists urged pre-Revolutionary War Americans (before 1777) to use bristle toothbrushes.

Toothbrushes and paste. The bristle brush was probably invented by the Chinese and brought to Europe during the seventeenth century.

Modern Brushes

Dr. Scott's "Electric Toothbrush" was marketed in 1880. Its manufacturer claimed the brush was "permanently charged with electro-magnetic current." The first real electric toothbrush was developed in Switzerland after World War II (1939-1945). This model, complete with electric cord, was introduced to the United States market in 1960 by the Squibb company under the name Broxodent. General Electric followed in 1961 with its rechargeable cordless model. Although it seemed an odd idea to many people at the time, the electric toothbrush was an immediate success.

Toothpaste

Like toothbrushes, compounds for cleaning teeth (and freshening breath) have been used since ancient times. Early Egyptian, Chinese, Greek, and Roman writings describe numerous mixtures for both pastes and powders. The more appetizing ingredients included powdered fruit, burnt shells, talc, honey, ground shells, and dried flowers. The less appetizing ingredients included mice, the head of a hare, lizard livers, and urine. Powder and paste formulas continued to multiply through the Middle Ages. Unfortunately, many of these recipes used ingredients that eroded (wore down) or abraded (nicked) the non-replaceable tooth enamel.

Modern toothpastes began to appear in the 1800s. Soap was added to tooth cleaners in 1824. Chalk was popularized by John Harris in the 1850s. Dr. Washington W. Sheffield, a Connecticut dentist, put his popular "Dr. Sheffield's Creme Dentifrice" in its collapsible tube on the market in 1892.

The toothpaste tube reigned supreme until 1984. Then the pump dispenser, which had originated in Europe, was introduced to the U.S. market. Fluoride, a chemical to fight tooth decay, was added to toothpaste in 1956, when Proctor & Gamble launched Crest toothpaste.

Tooth extraction devices

Early Procedures

In primitive societies teeth were extracted with a chisel-shaped piece of wood held against the tooth and pounded with a mallet. Early Chinese tooth-pullers used their fingers. These oriental dentists developed the necessary strength in their fingers for this task by spending hours pulling nails out of planks.

Tooth extraction devices

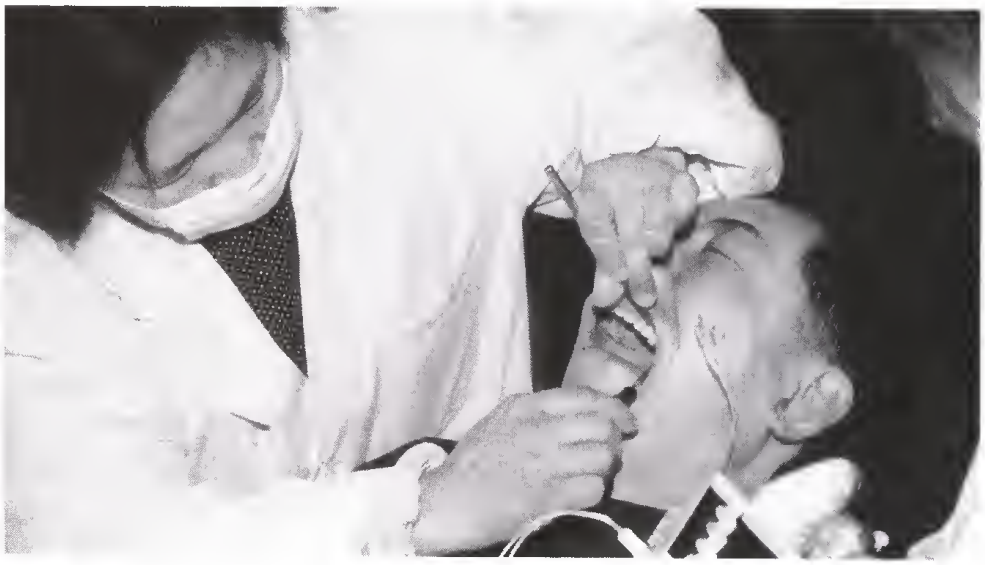
Origins of Dental Instruments

Around 300 A.D. the ancient Greeks used double-lever forceps to pull teeth while the Romans used forceps of various designs. These designs included a thin-root forceps and pliers to remove small pieces of tooth. Abulcasis (963-1013), an Arab surgeon from Spain, illustrated a number of dental extraction devices in his eleventh-century *Treatise on Medicine and Surgery*. These tools included elevator chairs, forceps, and lancets for loosening the gum.

Middle-Age Dentistry

In fourteenth-century England barber-surgeons regularly extracted teeth. Their familiar red-and-white barber poles were sometimes adorned with teeth they had pulled. Those poles were combination shop signs/advertisements used to indicate that they would also bleed the sick. In 1481 Johann Schrenk of Germany used and described a form of forceps called a pelican. A similar device was illustrated by famed French surgeon Guy de Chauliac (circa 1300-1370).

Renowned French surgeon **Ambroise Paré** (1510-1590) used a three-instrument approach to tooth extraction. This included a root-exposer to loosen the gum, a pusher to ease the tooth out of its socket, and a pelican to lift the tooth out. In the late 1500s Fabricius (1537-1619) described nine different pairs of forceps. Most were named for the mouth or beak of the animal or bird they resembled. In 1525 Thomaseus devised a heavy-toothed forceps.

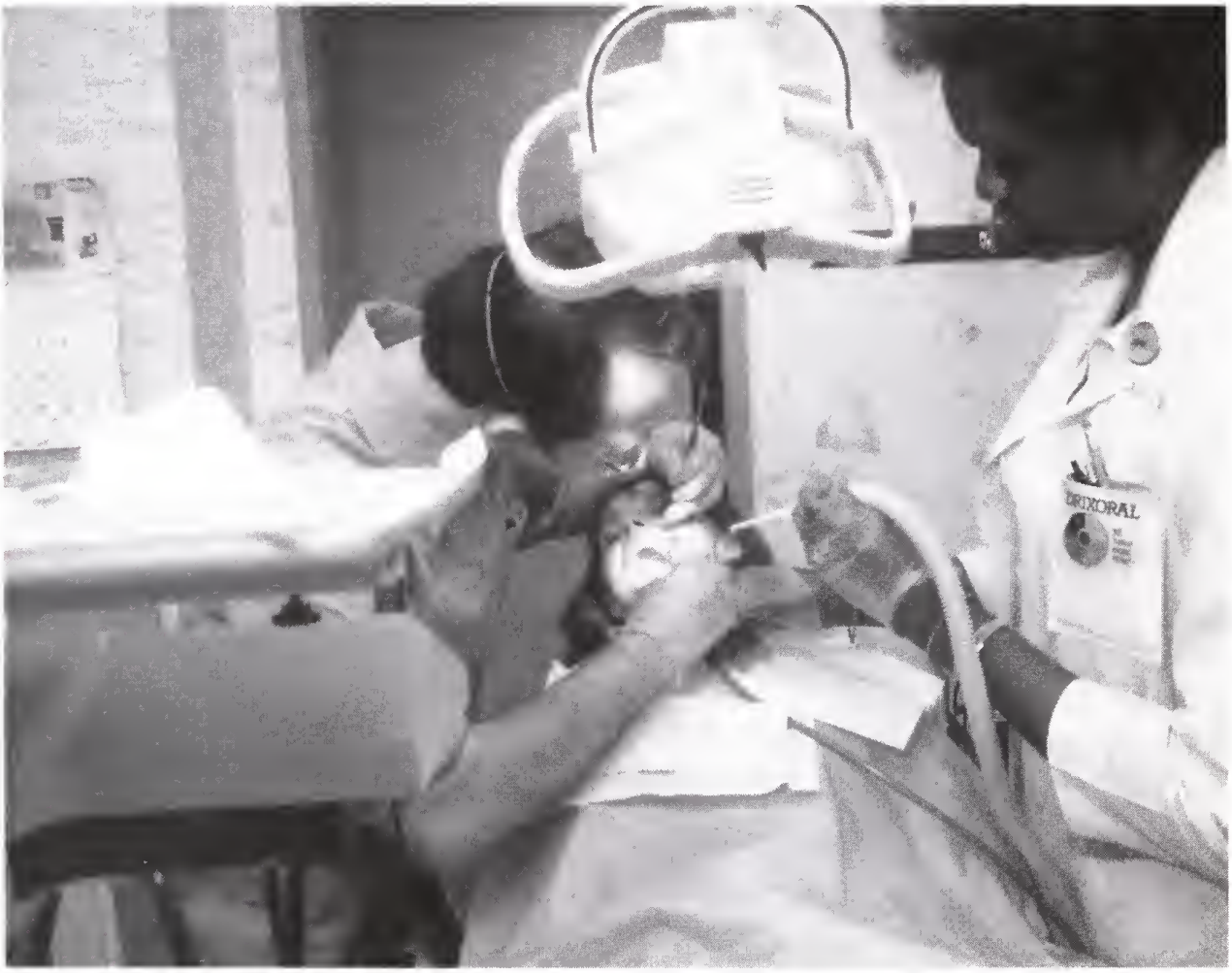


Acupuncture is used as an anesthetic during a tooth extraction procedure.

Anatomical Forceps

In the 1600s Dutch surgeon Anton Nuck advocated anatomical dental forceps. These were designed to fit the shape of the teeth they were to extract. Cyrus Fay, an American dentist practicing in London, built the first anatomical forceps in 1822. In 1841 John Tomes (1815-1895) of London also designed anatomically based forceps. Tomes's instruments were made by French toolmaker Evrard (1800-1882).

A tooth extractor called the dental key was first described in 1725 by Parisian J. C. de Garengeot. The device's origins are unknown but Garengeot improved the design. The key was different from the horizontal extractors used at that time. It featured a solid handle set at right angles to a long shaft. In use, it was turned until the tooth popped out. Unfortunately, the key-extracted tooth often broke, leaving the root behind. John Aitkins of London further refined the dental key in 1771. Between 1790 and 1840 the battle of the tooth extractors raged. The contestants were the horizon-



A patient has a tooth pulled. In the mid-1840s Americans Horace Wells and W. T. G. Morton used the first general anesthesia for tooth extraction—a mixture of nitrous oxide, or "laughing gas," and ether.

tal key and the new vertical tooth-extracting devices which pulled the tooth straight out.

Older Tools Still in Use

An improved elevator chair introduced by French dentist Lecluse in 1750 was still widely used well into the twentieth century. J. J. J. Serre of Vienna designed a screw for removing root remnants in 1790. Serre's tool (with certain modifications) continued in use into the 1900s. In the mid-1840s Americans Horace Wells and W. T. G. Morton used the first general **anesthesia** for tooth extraction—**nitrous oxide** ("laughing gas") and **ether.**

Tracheotomy

A tracheotomy is a potentially life-saving surgical procedure. During a tracheotomy, an opening is made in a patient's windpipe to relieve airway obstruction. A tube inserted into the trachea through the throat allows breathing to continue through the tube and bypasses the mouth and nasal passages. After the emergency has passed, the tube can be removed and the opening closed.

The first tracheotomy was performed in 1825 by French physician Pierre Bretonneau (1778-1862). Bretonneau operated on a four-year-old girl whose throat had become obstructed with the scar tissue, the result of diphtheria (a disease characterized by weakness, high fever, and the for-

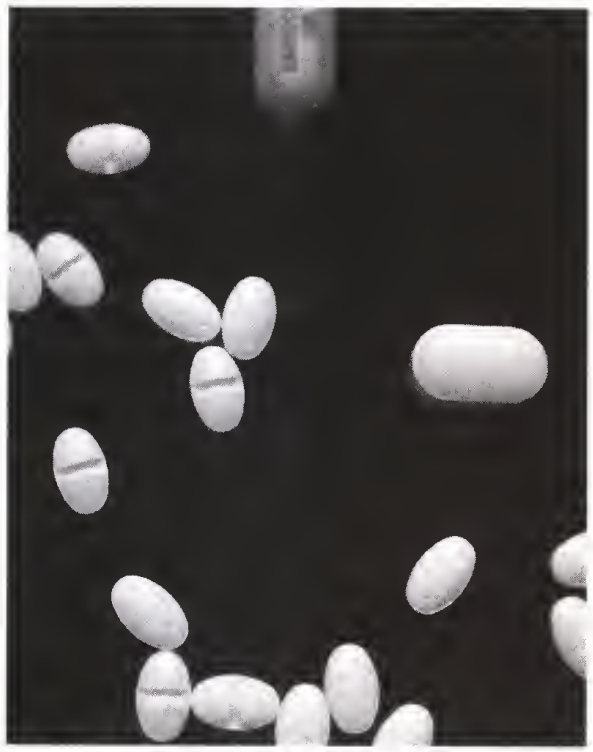
A tracheotomy patient. Tracheotomies are used today to treat choking victims, as well as patients with severe burns, respiratory infections, and cancer.

mation of membrane-like throat obstructions). Although Bretonneau had previously attempted two failed tracheotomies, his determination, skill, and dexterity paid off when he saved the girl's life.

Tracheotomies are used today to treat choking victims, as well as patients with severe burns, poliomyelitis, respiratory infections, and cancer.

Tranquilizers

Tranquilizers are substances that produce a state of calmness in agitated people. Minor tranquilizers—such as **barbiturates**—are used in the treatment of anxiety (fearfulness). Major tranquilizers are known as antipsychotics. Antipsychotics can alleviate symptoms of major psychotic illnesses (severe mental disorders that prevent patients from knowing the difference between what is real and what is fantasized). Schizophrenia (a severe disorder known for such symptoms as delusions, hallucinations, and inappropriate behavior) is an example of a major psychotic illness. In psychotic illness, normal thinking and the ability to interact appropriately with others deteriorates until patients withdraw from reality. Antipsychotics reduce the agitation and distress that patients feel, while providing the patients with emotional serenity (calmness) and indifference to what is going on around them.



A variety of tranquilizers.

Unlike minor tranquilizers, major tranquilizers of the antipsychotic type are not addictive. Patients generally do not build up a tolerance to them. Psychotic patients can take the drugs for years without needing to increase their dosage.

It is almost impossible to overdose on major tranquilizers. An overdose of barbiturates, however, can cause total respiratory arrest. Possible side effects that may be experienced with therapeutic (medicinal) use of antipsychotics include increased heart rate, dry mouth, blurred vision, and constipation.

Tranquilizers Found Useful for Anesthesia

The tranquilizer chlorpromazine was found to be beneficial during surgery by reduc-

ing the amount of anesthetic needed. Chlorpromazine appeared to profoundly alter patients' mental awareness: patients were conscious, yet they felt quiet, sedate, and unconcerned with events occurring around them.

These effects led doctors to try chlorpromazine in the treatment of mental illness. The doctors discovered that the drug relieved psychotic episodes (which occur when a person loses touch with reality). Patients who were institutionalized (living full time) in mental hospitals in the United States began to use antipsychotics in the early 1950s. The drug chlorpromazine allowed many such patients to recover enough to leave the hospital, helping to reduce the populations of mental hospital by two-thirds in less than 25 years. For the first time a drug had been discovered that targeted the central nervous system without profoundly affecting other behavioral or motor functions.

Reserpine

American doctors also tested a drug called Reserpine on mentally ill patients. The drug did not make patients sleepy and allowed them to participate in activities.

Reserpine and other tranquilizers produce positive results. They reduce the fear, hostility, agitation, delusions, and hallucinations experienced by seriously mentally ill people. (When healthy people take these drugs, however, they experience slower thinking and react more slowly.)

Despite initially positive results, Reserpine use steadily decreased as more patients experienced a number of side effects, including reduced blood pressure, diarrhea, and depression.

Other Options

In the 1960s Belgian scientists developed a class of drugs that later became available in the United States under the names haloperidol (Halol) and droperidol (Inapsine), increasing the number of treatment options for patients with mental illnesses.

Transplant, surgical

Stories of transplanted tissue and body parts go far back in myth and legend. It is said that in the sixth century, the Christian patron saints of medicine, Cosmos and Damian, performed a transplant. They replaced the cancerous leg of a white man with the healthy leg of a recently deceased black man.

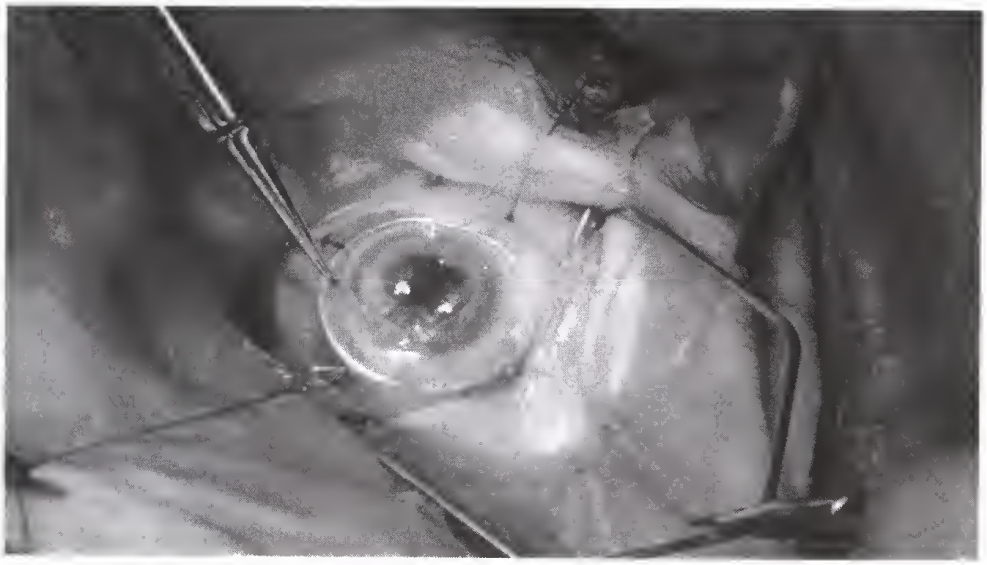
Skin Grafts

In India, **skin grafts** were done as far back as the sixth century B.C. to replace noses that had been amputated as a penalty for adultery. The Indian process of skin grafting was introduced to Western medicine by Italian surgeon Gaspare Tagliacozzi in the sixteenth century. He attached a skin flap from a patient's forearm to the patient's nose. Several weeks later, he released the arm from the now-repaired nose. Tagliacozzi used the patient's own skin because he felt that foreign body tissue would be rejected. Thus he correctly anticipated what is still the major problem with successful transplantation: rejection of foreign body tissue.

Skin grafting was reintroduced in the nineteenth century. In 1869 French surgeon Jacques Louis Reverdin found that successful grafts required thinner tissue. In 1881 Scottish surgeon William MacEwen reported success with bone allografts (transplants from one person to another) in children. Despite these reported successes, most attempts at transplantation failed. Inadequate surgical techniques or rejection by the recipient caused most failures.

Carrel's Techniques

In 1902 French surgeon Alexis Carrel developed a method of sewing together small blood vessels using tiny needles and fine thread. Carrel and Dr. Charles Guthrie of the University of Chicago performed a series of organ transplants on animals. While the transplants were at first successful and the organs functioned, they ultimately failed. Other experimenters had similar results.



A corneal transplant.

Rejection

Researchers who were experimenting with transplants suspected that the body's immune system was rejecting the implanted organs. They believed that it was the foreign tissue that was the problem.

British biologist Peter Medawar became interested in skin graft problems while working with severely burned soldiers during World War II (1939-1945). Medawar found that when a patient received a skin graft for a second time from the same donor, the second graft was rejected twice as quickly as the first had been. To Medawar, this clearly indicated an immune response. Further experiments revealed that grafts between twins were not rejected.

In 1954 Medawar went on to prove that immune tolerance was acquired during an embryo's development. Injection of foreign substances into embryonic or newborn mice would produce permanent tolerance to those substances later in life. In other words, the mouse's body would forever recognize such a substance as "self," instead of responding to it as a foreign invader in need of destruction by the immune system.

Kidney Transplants

Surgeons continued to experiment with transplants. They focused their efforts on the kidney because of its relatively simple blood supply system. In 1933 Russian surgeon Yuri Voronoy performed the first human **kidney transplant** in Kiev, Ukraine. This kidney transplant, like those performed in cities throughout the world all failed. One patient, a 26-year-old Boston doctor, lived for six months with his new organ.

A Boston team finally achieved success in 1954. A 24-year-old man was dying of kidney disease. He was referred, along with his twin brother, to the Boston team. The transplant from twin to twin succeeded. The door was now open. The Boston surgical team performed 23 successful identical-twin kidney transplants between 1954 and 1966. However, transplants between non-twins still resulted in rejection.

Attempts to suppress the immune response by radiating (exposing to **X-ray**) the recipient's body and the donated organ were unsuccessful. In the early 1960s two major breakthroughs finally addressed the rejection problem. Beginning in 1962, it became possible to closely match donor and recipient tissue. This technique markedly decreased the likelihood of rejection in transplantation.

Immunosuppressant therapy was greatly improved by the discovery of **cyclosporin** in 1972. The widespread use of cyclosporin ushered in the era of widespread organ transplantation. Again, Starzl showed cyclosporin

A Trans World Airlines pilot delivers an eye from a San Diego eye bank to a doctor at the Kansas City Medical Center. The cornea of the eye was later transplanted into the eye of a patient at the center.

era of widespread organ transplantation. Again, Starzl showed cyclosporin to be more effective when used with **steroids.**

Transplantation Today

The liver remains difficult to transplant because of its complicated blood supply. The first successful liver transplant was performed by Starzl at the University of Colorado in 1967. Cyclosporin greatly improved the outcome of such transplants. The first human pancreas transplantation was performed by Drs. Richard Lillehei and William Kelly of the University of Minnesota in 1966.

Physicians found that transplantation of both lungs succeeds better than transplanting a single lung. Because most patients with end-stage lung disease also have serious heart deterioration, heart-lung (both lungs) transplants are sometimes performed. The success of this operation is aided by cyclosporin. The first successful heart-lung transplant was carried out in 1981 at Stanford University Medical Center by Drs. Bruce Reitz and Norman Shumway.

Other body parts are now transplanted, but problems remain. Many grafts do not survive permanently. Cyclosporin is very expensive and has serious side effects. Still, a 1992 government report found that organ transplants in the United States were largely successful. Favorable outcome rates vary according to the organ transplanted.

[*See also* **Barnard, Christiaan; Kidney transplant**]

Tuberculin test

Tuberculin tests are administered to patients for the diagnosis of tuberculosis (TB). Tuberculosis is a serious bacterial disease that attacks the lungs. The tubercle bacillus that causes the disease was discovered by German bacteriologist **Heinrich Robert Koch** (1843-1910) in 1882. Eight years later, Koch was the first researcher to find a way of diagnosing the disease. Koch's test to demonstrate sensitivity to the tubercle bacilli won him the 1905 Nobel Prize for medicine.

Testing Methods

There are several ways of testing for the presence of TB. In the laboratory, sputum (spit or phlegm) from a person can be examined for the presence of the TB bacteria.

A officer at the Queensboro State Prison in New York (right) receives a tuberculin test from a nurse as part of a 1991 mandatory tuberculosis testing program.

Tuberculin test

More common are those tuberculin tests which are administered on the skin. The three types of skin test used consist of either a patch test, tine test (multiple puncture) or an injection. In each case a derivative of tuberculin (measured in TU or "tuberculin units") is used and placed on the skin. Forty-eight hours later, the scratched area is examined for inflamation. If there is a hardening of the skin on the scratched area, the hardening indicates that the person was at some time infected with the TB bacteria.

A positive test, however, does not indicate that a person has active TB. Anyone who has been immunized against TB will likely show a positive result. The skin test currently used was developed by Dr. Florence B. Seibert, a biochemist. Seibert first isolated the active protein in tuberculin and used it to make TB skin tests more accurate. The substance used in a TB test is a purified protein derivative (PPD) which comes from the filtrates of laboratory cultures of tubercle bacilli. If a person shows an inflammatory reaction, a physician will usually recommend a chest **X-ray** to see if there is a spot on the lung. This would confirm that the disease is present in the body.

Ultrasound devices

Before the development of ultrasound devices, there was no way to safely diagnose the condition of a fetus (name given to unborn young from the end of the eighth week of development through birth). **Prenatal surgery** was extremely risky for both the mother and the unborn child. The other diagnostic method available was the use of **X-ray** radiation. But prolonged exposure to X-rays was hazardous, especially to a fetus. In fact, a 1958 study showed that there was a much higher rate of leukemia (a blood disease in which there are too many white blood cells) among children exposed to radiation in utero (in the womb).

Before the development of ultrasound devices, there was no way to safely diagnose the condition of a fetus.

The same year that study appeared, however, a new science was introduced called ultrasonography. Using ultrasound technology, physicians were able to observe the condition of an unborn child using high-frequency sound waves. These sound waves created no apparent danger to the child or the mother.

Ultrasound Development

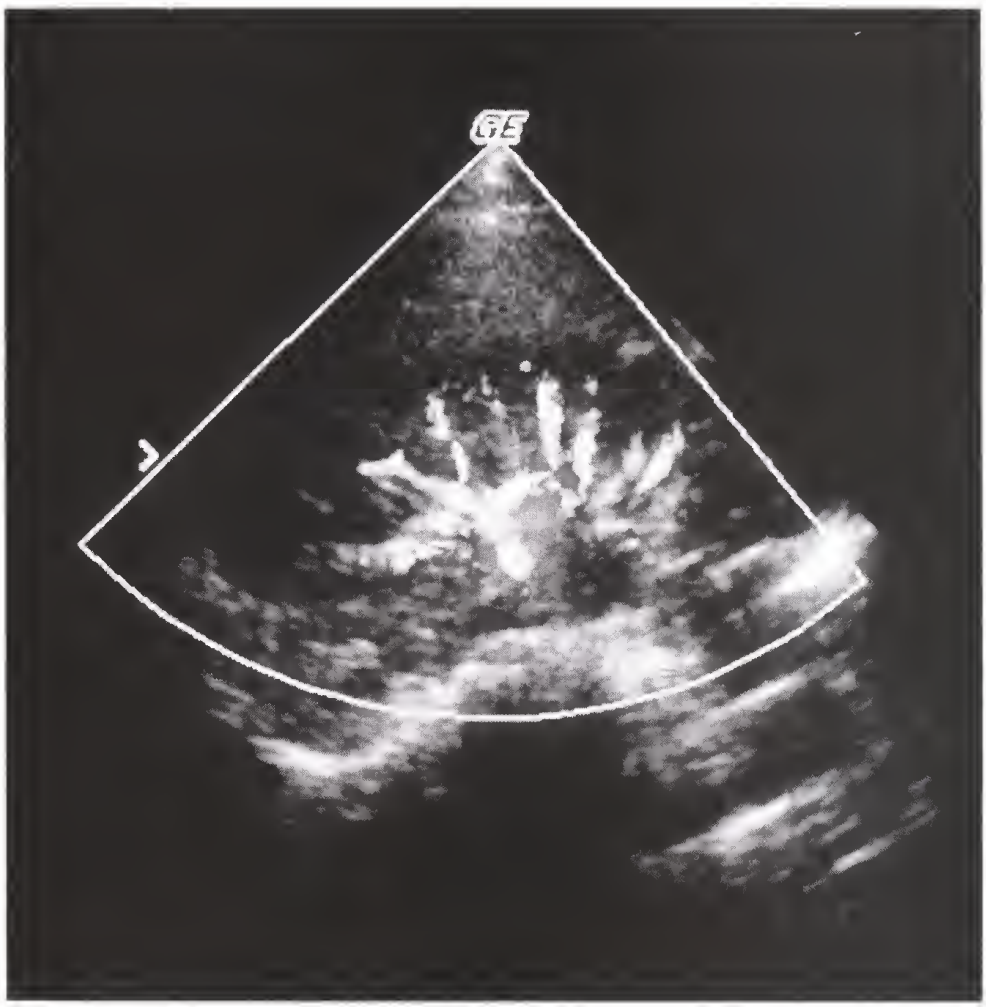
The man most responsible for the development of ultrasound technology was British physician Ian Donald. Donald served in the British Royal Air Force during World War II (1939-1945). At that time, top secret experiments were being conducted on radar and sonar devices. Following the end of the war the technology was released to the scientific community. This was about the same time Donald began his medical career.

Ultrasonics was first used to test machine parts. It detected cracks, flaws, and bubbles in the metal. Donald was certain that ultrasonics could

be applied in medicine, particularly in his field of obstetrics (the care of women during pregnancy). In the early 1950s he began working with engineers to modify the devices to observe the human body.

Donald's ultrasonic device for medical diagnosis was first tested in 1957. With it, Donald used sound waves to correctly diagnose a patient's heart condition. A year later the procedure called ultrasonography was being used on pregnant women.

Since the 1960s improvements to ultrasonographic technology have made it the most common procedure for observing the fetus. The information gained helps obstetricians in treating individual pregnancies. In the thousands of ultrasonographs performed, no evidence of harmful effects has been found. Because of the safety of the procedure, ultrasonics has been applied to the diagnosis of other delicate organs. These organs include the heart, lungs, and kidneys.



An ultrasound picture of a patient's kidneys.

How Ultrasonics Works

Ultrasonics works because sound waves of very high frequencies can easily and harmlessly penetrate human flesh. As the waves enter the body, they encounter substances of different densities, such as bone and internal organs. These different densities bounce back the waves differently to the wave source. Because each substance makes the waves reflect differently, physicians can identify the type of tissue by the type of reflection. An ultrasound machine uses the different signals to create a picture of the inside of the body.

Ultrasonic Treatment

Ultrasonics is now being used in the treatment of certain conditions as well as for observation. A device called the Cavitron was invented in 1980. It focuses a narrow beam of sound waves on a tumor. The sound waves break up the tumor without removing it from the body. A similar method is used to pulverize (break into pieces) gall stones (small, hard objects that form in the gall bladder), making their passage much less painful.

The Cavitron is an effective tool for treating ailments that previously required invasive surgery. It is particularly useful in the treatment of brain tumors.

Ultraviolet radiation

Just like visible light, infrared light, and radio waves, ultraviolet light is electromagnetic radiation. Ultraviolet light lies on the spectrum between violet light and **X-rays**. Although ultraviolet radiation is undetectable to the naked eye, anyone who has been exposed to too much sunlight has probably noted the effects of ultraviolet light. It is this form of radiation that causes tanning and sunburn, types of skin damage which can lead to skin cancer.

Ritter's Experiments

The man credited with the discovery of ultraviolet light is German physicist Johann Ritter (1776-1910). Ritter experimented with silver chloride, a chemical known to break down when exposed to sunlight. He found that the light at the blue end of the visible spectrum (blue, indigo, and

violet) was a much more efficient stimulant for this reaction. Experimenting further, Ritter discovered that silver chloride broke down most efficiently when exposed to radiation just beyond the blues. He called this new type of radiation ultraviolet, meaning "beyond the violet."

Ultraviolet Radiation and the Body

While ultraviolet radiation in large doses is hazardous to humans, a certain amount is actually required by the body. As it strikes the skin, ultraviolet rays activate the chemical processes that produce **vitamin D.** In areas that lack adequate sunshine, children are often plagued by rickets (a disease characterized by abnormally shaped and structured bones). In order to treat these cases, or to supplement natural light in sun-starved communities, ultraviolet lamps are often used.

Three Types of Lamps

There are three varieties of ultraviolet lamps, each producing ultraviolet light of a different intensity. Near-ultraviolet lamps are fluorescent lights whose visible light has been blocked, releasing ultraviolet radiation just beyond the visible spectrum. These lamps are also known as black lights, and are primarily used to make fluorescent paints and dyes "glow" in the dark. This effect is often used for entertainment, but can also be used by industry to detect flaws in machine parts.

Middle-ultraviolet lamps produce radiation of a slightly shorter wavelength. They generally employ an excited arc of mercury vapor and a specially designed glass bulb. Because middle-ultraviolet radiation is very similar to that produced by the sun, these lamps are frequently used as sunlamps. They are often found in tanning salons and greenhouses. Photochemical lamps generating middle-ultraviolet light are also used in chemical laboratories and industrial settings to induce certain chemical reactions.

Far-ultraviolet lamps produce high-energy, short-wavelength ultraviolet light. Like middle-ultraviolet lamps, they use mercury-vapor tubes. Far-ultraviolet radiation is easily absorbed by glass, so the lamp's bulb must be constructed from quartz. Far-ultraviolet light has been found to destroy living organisms such as germs and bacteria. These lamps are often used to sterilize hospital air and equipment. Far-ultraviolet radiation has also been used to kill bacteria in food and milk, giving perishables a much longer shelf life.

Vesalius, Andreas

Andreas Vesalius (1514-1564) is widely credited with developing modern anatomical studies. Vesalius was born in Brussels, Belgium, to a family established in medicine for several generations. Young Vesalius showed an early interest in anatomy. He attended the University of Louvain, then studied medicine at the University of Paris, where he became skilled at dissection under teachers who were dedicated followers of **Galen,** the ancient Greek physician.

Andreas Vesalius.

Early Career

After a working as a military surgeon, Vesalius enrolled at the University of Padua (Italy), receiving his medical degree in 1537. As soon as he became a lecturer at the university, he began to establish new ways of teaching and demonstrating anatomy. Contrary to the standard practice, Vesalius performed dissections himself during lectures and illustrated the lesson with large, detailed anatomical charts. The lectures were enormously popular and demand for the charts was so great that Vesalius had them printed.

As Vesalius proceeded with his dissections, he increasingly noted obvious conflicts between what he saw in the human body and what Galen described. Galen's errors, Vesalius

reasoned, arose because the ancient anatomist relied only on animal dissections, which often did correlate to human anatomy. (Galen was not allowed to dissect human bodies because of religious restrictions.) Vesalius set down the principle that true, fundamental medical knowledge must come from human dissection, practiced by each individual physician.

Vesalius Writes a Book

To attract established physicians to the study of anatomy, Vesalius wrote one of the most important books in medical history. Published in 1543, it was the world's first textbook of anatomy called *De humani corporis fabrica* ("The Fabric of the Human Body"). Vesalius carefully supervised all aspects of the book's production. The *Fabrica* contained detailed anatomical descriptions of all parts of the human body, including directions for carrying out dissections, magnificent, detailed illustrations, probably by students from the famous painter Titian's studio, and a clear explanation of the objective, scientific method of conducting medical research.

The publication of the *Fabrica* rocked medicine to its foundations and was the subject of bitter controversy. For reasons not exactly clear, Vesalius abruptly quit anatomical research and became court physician to two kings. In 1564 he left Spain for a trip to the Holy Land (Palestine), perhaps intending to return to teaching in Padua. On the way back from Palestine, however, his ship was wrecked. Vesalius died on the island of Zante at the age of fifty.

Vitamin

Vitamins are organic compounds (mixtures made from living organisms like plant and animal tissue). They are generally divided into two groups: fat-soluble and water-soluble. Fat-soluble vitamins include vitamins A, D, E and K. Water-soluble vitamins are those in the B group and **vitamin C.**

Many people think they can improve their health by taking vitamin pills. Most medical experts believe this is unnecessary. The experts say that eating a varied diet of fresh food and exposing the skin to enough sunlight to increase **vitamin D** reserves (but not enough to burn the skin) should provide enough vitamins under most circumstances. In fact, overdosing on some vitamins can itself cause disease.

Only tiny amounts of each of the 13 vitamins are needed to ensure metabolism, but these minimum amounts are absolutely essential. The continued lack of any vitamin, even in an otherwise balanced diet, usually leads

How Vitamins Got Their Names

In the early part of the twentieth century, Polish biochemist Casimir Funk studied the various "accessory food factors" that had been identified. He suggested these factors be named "vitamines" or "amine compounds vital for life" (amines are organic compounds of nitrogen). After it became clear that not all these compounds were amines, the final "e" was dropped, and the substances became known as vitamins.

to a deficiency disease. Vitamins were discovered as scientists searched for the causes of deficiency diseases like pellagra, beriberi, and scurvy.

Vitamins and Enzyme Reactions

While vitamins are not all chemically related, they all serve a common purpose. That purpose is helping to regulate how the body converts food into energy and living tissues (metabolism). Most vitamins accomplish this by acting as **enzymes.** Enzymes are chemicals which encourage chemical reactions, but are neither changed by the reaction nor are they incorporated into the reactions's final product.

Many vitamins, including all of the eight vitamins in the B group, are inactive until converted into coenzymes. Coenzymes are organic substances which combine with a protein to form an active enzyme system. The human body needs vitamins to work properly. We acquire almost all of the vitamins from the foods we eat. A small number of vitamins, including biotin and **vitamin K,** are at least partially synthesized (created) by the body itself.

[*See also* **Biotin; Vitamin A**]

Assorted vitamin pills. Only tiny amounts of each of the 13 vitamins are needed to ensure metabolism, but these minimum amounts are absolutely essential.

Vitamin A

Since its discovery in the early part of the 20th century, researchers have learned a great deal

about vitamin A. They now know that this once-mysterious compound is essential for normal growth and development, maintaining the body's skin cells, and forming part of the two pigments needed by the retina to help the eye adjust to varying degrees of light.

McCollum's Research

By 1906 English biochemist **Frederick Gowland Hopkins** (1861-1947) was looking into what he termed "accessory food factors." But the scientific community generally believed that all dietary needs could be met by proper amounts of carbohydrates, proteins, fats, minerals, and water. The concept of trace nutrients was largely unknown.

In 1907 Elmer McCollum joined the University of Wisconsin as an instructor. Born and raised in Kansas, McCollum had recently received his doctorate from Yale University. McCollum originally studied inorganic chemistry, but had switched to biochemistry simply because no position was immediately available in his chosen field. Biochemistry was known as agricultural chemistry at the turn of the century.

The first research project McCollum was assigned to was to study the effects of different single-grain diets on dairy cattle. It was assumed that the three chemically similar grains would have similar dietary effects. To the research team's surprise, however, only the corn-fed cows remained healthy. Those animals that were fed wheat or oats did not thrive. McCollum was immediately intrigued. He reasoned that there must be some undiscovered difference in the structures of the similar foods.

Before long, McCollum was designing his own nutritional studies. Because he felt that dairy cattle were too cumbersome to work with, he set up a colony of albino rats. This was the country's first such colony devoted to experimental research. McCollum was assisted in his work by Marguerite Davis, a recent University of Wisconsin graduate. It was in his own laboratory that the studies began that would make him famous.

By 1913 McCollum reported that when laboratory rats were put on diets in which lard or olive oil was the only source of fat they eventually stopped growing. These same rats, however, quickly resumed normal growth when fed extracts of eggs or butter. McCollum concluded that butterfat and egg yolks must contain some growth-promoting factor missing in other fats.

The Missing Ingredient

Within two years, McCollum had isolated the growth-promoting factor. He named it "fat-soluble A" to distinguish it from a water-soluble

factor. The water-soluble factor was previously discovered in rice polishings by **Christiaan Eijkman** (1858-1930). McCollum termed Eijkman's discovery "water-soluble B." Fat-soluble A was soon known as vitamin A, the first vitamin actually to be named and described.

[*See also* **Eijkman, Christiaan; Hopkins, Frederick Gowland; Vitamin**]

Vitamin B12

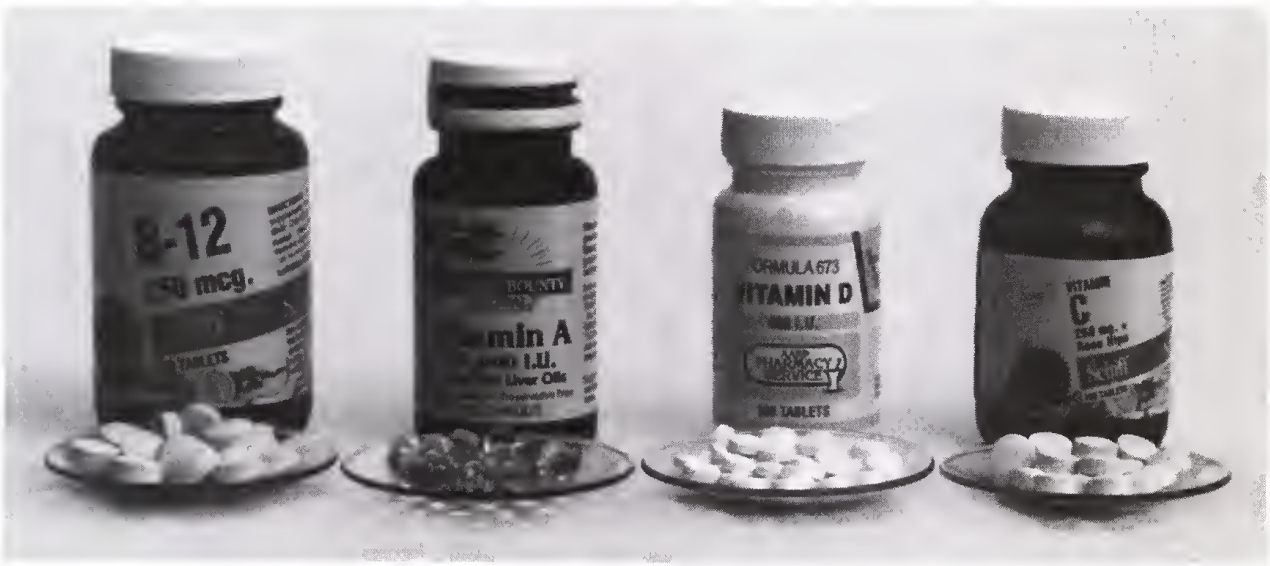
Vitamin B12 was discovered simultaneously by two research teams, one in the United States and one in England. It was the culmination of an intensive worldwide search for a compound that could effectively treat pernicious anemia.

B12 and Liver

During the 1930s, researchers around the world began trying to isolate the active ingredient in liver that contained its curative properties. The "antipernicious anemia factor" was believed to be a B vitamin. It was even given the name B12 long before it was isolated.

Testing was surprisingly slow. Patients were fed extracts of liver rather than the liver itself, but for some reason researchers could not measure the amount of vitamin B12 these liver extracts contained. They could only guess at the extracts' potency by measuring red blood cell growth in each patient's blood.

Vitamins on display.



Pernicious Anemia

Pernicious anemia is a blood disorder in which red blood cells fail to develop normally. The steady decline of red blood corpuscles eventually leads to death. The disease was first described completely in 1849 by English physician Thomas Addison (1793-1860). Addison noted the typical symptoms included increasing weakness and pallor of the patient. This was accompanied by obesity (weight gain) rather than weight loss.

Until the 1920s, this pernicious anemia was always fatal. Then two physicians named George Richards Minot (1885-1950) and William Perry Murphy became inspired by George Whipple's (1878-1976) studies. The Whipple studies showed that beef liver could improve the formation of red corpuscles in anemic dogs. To test Whipple's findings, Minot and Perry began feeding their patients large amounts of beef liver. In 1926, the researchers were able to announce that a daily diet of about a half a pound of liver could control the disease. For their work, Minot, Murphy, and Whipple shared the 1934 Nobel Prize in medicine.

For years, Karl Folkers, an American chemist at a prominent pharmaceutical company, had been directing a research team that was working on the problem. In 1948, the group finally came up with a solution. They found they could measure the vitamin indirectly by measuring the growth rate of certain bacteria that needed vitamin B12 to grow. This system speeded the purification process of the vitamin enormously.

The New Vitamin

The new **vitamin** was a large and complicated molecule roughly four times the size of a **penicillin** molecule. The molecule was so complex that its structure could only be worked out through the aid of advanced technology. In 1956 English physicist Dorothy Hodgkin (1910-) completed the mapping of B12's chemical structure by using **x-ray crystallography**. She received the 1964 Nobel Prize in chemistry for her work. Vitamin B12 was finally synthesized by Robert Burns Woodward (1917-1979) in 1971, after a ten-year effort.

The isolation and synthesis of B12 removed pernicious anemia from the list of deadly medical problems. B12 was the last vitamin to be dis-

covered. Work on the vitamin served to round out the remarkable half-century of vitamin research that began in the 1890s with Dutch physician **Christiaan Eijkman** (1858-1930).

Vitamin C

Unlike other water-soluble vitamins, vitamin C (ascorbic acid), does not appear to act either as a catalyst or as a coenzyme. Instead, it plays a major role by regulating the formation of collagen. Collagen is a protein that makes up connective tissue. This tissue is found in skin, bones, cartilage, teeth, muscles and the walls of blood vessels. Vitamin C is also an important antioxidant. It helps protect **vitamin A, vitamin E,** and various fatty acids from the damage caused by excessive oxidation.

Because very little vitamin C is stored in the body, a daily dietary source is necessary. The vitamin is found almost exclusively in fruits and vegetables, particularly in citrus fruits such as oranges and lemons.

Interestingly, most animals are able to synthesize their own vitamin C. Only primates, guinea pigs, and a few fairly exotic creatures (such as the Indian fruit bat) need to get this vitamin from food.

Today cereals, infant formulas, and other foods are often supplemented with vitamin C, so that a serious deficiency is quite rare. Vitamin C deficiencies were common up until the early 20th century. They generally occurred during the winter months, occasionally lasting long enough to produce scurvy.

[*See also* **Enzyme; Vitamin; Vitamin A**]

Scurvy

Scurvy is a debilitating and potentially fatal disease caused by a prolonged lack of vitamin C, leading to problems with the body's connective tissues. An early symptom of scurvy occurs when the walls of the smaller blood vessels become dangerously fragile and begin to rupture. The patient's gums bleed and small hemorrhagic spots appear on the skin. In later stages, teeth loosen and fall out, bones weaken, joints become swollen and painful, and anemia may develop. Additionally, wounds fail to heal because connective tissue is needed to repair cuts in the skin. Unless the disease process is halted, death results.

Vitamin D

Vitamin D is one of the four fat-soluble vitamins. It is concerned with efficient **calcium** and phosphorus absorption. The **vitamin** works with various hormones to ensure that calcium and phosphorous are absorbed from the intestinal tract in the right proportions into the bloodstream. Calcium and phosphorous in the right ratio and amounts help determine normal bone growth. In addition, vitamin D stimulates the bones to accept calcium.

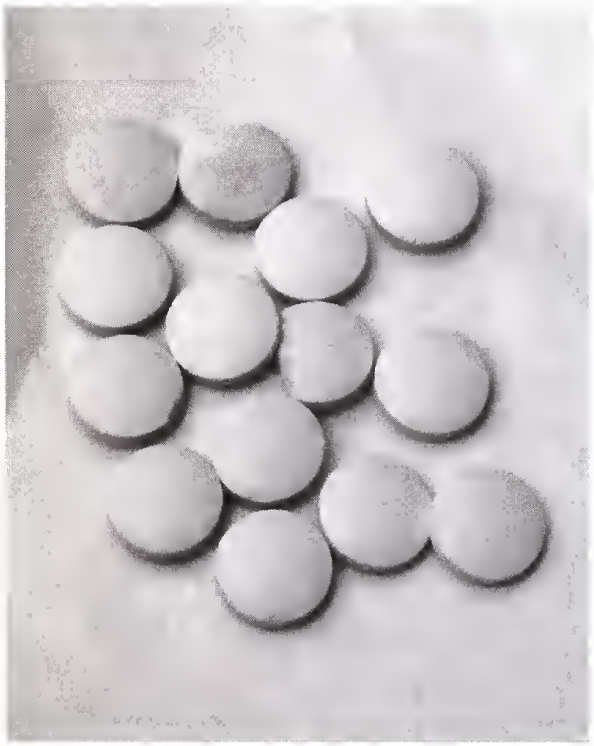
Vitamin D isn't just one vitamin but, a group of vitamins. All vitamins in the group are come from a parent compound structurally similar to cholesterol. The compound comes in a variety of forms, two of which are especially important from a nutritional standpoint.

Vitamin D2

Vitamin D2 (calciferol) is produced when ultraviolet radiation activates a sterol (fat-like substances in the **steroid** family) that is present mainly in yeasts and fungi (molds). Vitamin D2 is rarely seen in nature. It is manufactured in the laboratory and is regularly added to infant formulas and other fortified foods.

A Sunshine Vitamin

Vitamin D pills.



Vitamin D3 (cholecalciferol) is derived from a sterol present in animal tissues. In humans the sterol is converted into vitamin D on the skin's surface. The conversion is activated by ultraviolet rays from the sun. For this reason, healthy adults who are exposed to normal amounts of sunlight may produce enough vitamin D to avoid the need for added dietary sources.

Rickets

The need for vitamin D is greater in childhood. In infants and young children, lack of the vitamin can cause rickets (or rachitis). Rickets is a bone disorder that results in bowed legs, knock-knees, curved spines, and other abnormalities. Children with rickets have been discussed since **Galen**'s time (A.D. 130-200). A detailed description of rickets was provided as early as the seventeenth century. The cause of rickets, however, wasn't discovered until fairly recently.

Early Research

In 1914 England's Medical Research Council asked Edward Mellanby (1884-1955) to concentrate on finding a cure for rickets. Mellanby was a brilliant young English biochemist and a student of famous researcher **Frederick Gowland Hopkins** (1861-1947). Mellanby spent the next seven years at Cambridge University conducting feeding experiments on dogs. He was convinced that rickets had a dietary basis.

Mellanby finally devised a diet that helped him prove he could cure rickets. He did so by adding certain fats to his animals' rations. In 1921 Mellanby wrote that the fats' effectiveness in rickets was due "to a vitamin or accessory food factor they contain."

This "food factor" was probably identical to the fat-soluble vitamin that American scientist Elmer McCollum was working with. In 1922 McCollum and his associates discovered that their fat-soluble vitamin consisted of two separate vitamins. The first was **vitamin A** and the second vitamin they named vitamin D.

In that same year, McCollum and his group confirmed that cod liver oil was an effective treatment for rickets. Cod liver oil had been a folk remedy used to treat rickets for many years.

Ultraviolet Light

A number of researchers went on to show that when the skin was exposed to sunlight or ultraviolet light, a substance virtually identical to vitamin D is produced.

Independent researchers like Alfred Hess (1875-1933) and Harry Steenbock (1886-1967) continued to work on vitamin D. In 1924 Hess and Steenbock found that foods exposed to ultraviolet light developed substantially greater anti-rickets potency. This discovery led to the practice of irradiating certain foods (exposing them to low-level radiation) like milk to help prevent rickets.

[*See also* **Hormone; Ultraviolet radiation; Vitamin A**]

Vitamin E

Vitamin E was discovered in 1922 by Herbert M. Evans and K. S. Bishop. The researchers found that laboratory rats failed to reproduce when lard was their only source of food fat. According to the researchers, there was

Vitamin E capsules.

a compound in both wheat germ and lettuce that corrected the problem.

For a time, the unknown component was termed the "anti-sterility factor." In 1925 Evans decided that the component should be renamed vitamin E since the last vitamin to be discovered was **vitamin D.**

The new vitamin was fat-soluble. Studies by Evans and his coworker Gladys A. Emerson (1903-) showed that vitamin E deficiency caused two different problems. It caused reproductive problems in both sexes of small laboratory animals. It also caused a muscle dystrophy in many species of animals. But for almost three decades, investigators were not certain whether vitamin E had any effect on humans.

Vitamin E Isolated

Evans and Emerson isolated vitamin E from wheat germ oil, corn oil, and cotton seed oil in 1936. In 1938 it was synthesized by Paul Karrer (1889-1971) and his co-workers. The investigators decided the vitamin's biochemical function was primarily a protective one. Its purpose is to help prevent unsaturated fatty acids from combining with oxygen. When the acids and oxygen do combine, tissues break down. Other antioxidants include **vitamin C** and the trace element selenium.

At first, vitamin E was believed to regulate tissue-damaging oxidation almost entirely in animals. But nutritional surveys in the 1940s and 1950s revealed otherwise. Premature infants and patients with malabsorption illnesses were found to have low levels of blood tocopherol. Those same surveys also showed they had other blood irregularities as well. In 1968, vitamin E was finally recognized as an essential nutrient for humans.

Other Functions of the Vitamin

Vitamin E is believed to help maintain the structure of muscle tissue and various components of the reproductive system, vascular system, and nervous system. Even with this knowledge, there may be other functions the vitamin performs that researchers are not aware of. There is little evidence to suggest, however, that vitamin E supplements can help repair existing damage.

[*See also* **Vitamin**]

Vitamin K

Vitamin K promotes the formation of prothrombin and other blood-clotting proteins in the liver. A deficiency in the vitamin leads both to a slowdown in the clotting process and the strong possibility of a hemorrhage (excessive bleeding).

Dam's Hens

Research into vitamins began in 1929. Danish biochemist Carl Dam (1895-1976) noticed that his laboratory hens developed small hemorrhages (areas of blood vessel breakage) under the skin and within the muscles. Because the hemorrhages resembled those seen in scurvy, Dam first treated the hens for that disease. He added **vitamin C** in the form of lemon juice to his hens' diet. When that failed to stop their bleeding, he tried other additives. He ended up trying all the food additives that other investigators had found useful in correcting vitamin deficiencies. None of them worked.

Dam concluded that an unknown vitamin must be involved. Since the mysterious vitamin appeared to be essential for normal coagulation (clotting) of the blood, Dam named it vitamin K, for "Koagulation" (the German spelling of "coagulation").

The Search Begins

Intrigued by the thought of a new and potentially useful vitamin, others took up the challenge of the search. Within a few years, several biochemists were able to isolate the vitamin from an extract of alfalfa. An American group led by Edward Doisy (1893-1986) discovered that the alfalfa extract consisted of two chemically similar yellowish oils. The oils became known as K1 and K2. Doisy's group went on to work out the chemical constitution of both varieties. Because of this work, Doisy shared the 1943 Nobel Prize for medicine with Dam.

Vitamin K Deficiencies

Vitamin K deficiencies are relatively rare. The vitamin is widespread in plants and it is also synthesized by the bacteria in the human intestinal tract. Because antibiotics often destroy all types of bacteria in the body, patients on long-term drug therapy may need vitamin K supplements to prevent bleeding problems.

Newborn infants are particularly susceptible to vitamin K deficiency. This is because the vitamin does not pass easily from the mother to the fetus through the placenta (birth sac). In addition, all babies are born with a sterile digestive tract.

Because of this, newborns often receive an intramuscular injection of vitamin K at birth. The vitamin is also routinely added to infant formula. This helps prevent hemorrhages. Infants can only begin to synthesize their own vitamin K several days after birth. This is when the digestive tract has acquired the necessary bacteria.

[*See also* **Antibiotic**]

Watson, James Dewey

James Watson (1928-) is one of the most famous scientists of the twentieth century. He is recognized as a co-discoverer of the structure of deoxyribonucleic acid (DNA) and was a co-recipient of the 1962 Nobel Prize in medicine for his work in genetics.

Watson was born in Chicago, Illinois. He was an extremely intelligent child and used his photographic memory to his advantage. By age ten he was a regular contestant on a popular radio show called *The Quiz Kids*. He studied zoology at the University of Chicago when he was only 15 years old. By age 19 he was conducting research on viruses at the University of Indiana, where he earned his doctoral degree. He continued his virus work in Denmark for a short period of time before several scientists convinced him to concentrate on genetics and molecular biology. This new direction led him to Cavendish Laboratory at Cambridge University in 1951. It was here that he first met **Francis Harry Compton Crick** (1916-).

James Dewey Watson.

Watson Meets Crick

A friendship soon developed between Watson and Crick. It didn't take long before Watson's enthusiastic approach to genetic research persuaded Crick to assist him in developing a

DNA model. During this time DNA research was not a high priority for most scientists. Watson and Crick entered the race to find the structure of DNA rather late.

With the odds stacked against them, Watson and Crick proceeded to develop their own hypothesis. They believed the DNA structure was actually made of two parallel strands. They obtained structural working models and attempted to fit the pieces together using proven chemical laws and prior studies. Many times the model, which resembled a large tinker-toy ladder, fell apart or simply did not fit previously established evidence. The researchers tedious task was somewhat like trying to put together a model airplane with only a small portion of the instruction sheet and no picture of how the assembled plane should look.

Finally, two major clues fell into place. Watson and Crick knew that the amounts of the base pairs of amino acids (protein elements) which connect the two strands of the DNA molecule, were about the same size and shape. Information supplied by Maurice Wilkins and Rosalind Elsie Franklin also suggested that the sugar-phosphate part of the structure was on the outside of the model. Watson noticed that the base pairs fit neatly into the overall twisted ladder or double helix form without any distortion. It also meant that each side of the ladder fit into the other.

This explained how DNA could be precisely copied each time a cell divides. The completed model consisted of a double backbone of sugar and phosphate molecules arranged in repeating units. Between these, like rungs in a ladder, were the flat pairs of bases.

A Discovery Is Announced

In 1953 when Watson was only 25 years old, he and Crick announced their discovery. Almost ten years later, after numerous tests confirmed their results, the research team shared the Nobel Prize with Maurice Wilkins.

Today we know that DNA is the molecule that contains the essential set of directions that each cell needs to perform vital life functions. The details of the DNA molecule are so precise that differences in the microscopic structure could mean the difference between a man and a mouse, or between life and death.

A Busy Man

Since the DNA discovery Watson has published numerous papers, written several genetics textbooks, and taught at the California Institute of Technology and Harvard University. Watson divides his time between two demanding administrative positions. He is director of the prestigious

Cold Spring Harbor Laboratory in New York (an institution involved in genetic and cancer research). Since 1988 he has also been a director of the human genome project. The goal of this endeavor is to eventually identify all of the 50,000 to 100,000 human genes. Watson believes that this will make it easier to identify individuals who are at risk of developing a variety of genetically caused diseases.

[*See also* **Gene**]

X-ray

X-rays are electromagnetic waves, like light waves, but with a wavelength about 1,000 times smaller. Because of this very short wavelength, X-rays can easily penetrate low-density material, such as flesh. They are reflected or absorbed, however, by high-density material such as bone. The picture made by an X-ray machine shows the denser materials (like bones) as dark areas.

X-Ray Discovery

In 1895 German physicist Wilhelm Roentgen (1845-1923) was experimenting with a **cathode ray tube**. The tube produced weak rays that caused a screen to fluoresce (glow). To create a controlled environment, Röntgen placed the cathode tube in a black cardboard box that was too thick for cathode rays to penetrate. Once the cathode ray tube was turned on, however, he noticed that another screen across the room began to glow. Since this second screen was too far from the tube for cathode rays to reach, especially through a layer of cardboard, Roentgen realized that he had discovered a new type of ray.

Through experimentation Roentgen found that this new ray was able to penetrate even the thick walls of his laboratory. Roentgen delivered a paper detailing his findings on December 28, 1895. In the paper he admitted that he did not know the precise nature of these new rays. He chose to name them "X-rays," since "X" is the mathematical symbol for the unknown.

Few discoveries have been accompanied by as much fanfare as the X-ray. During the 12 months following the publication of Roentgen's

paper, more than 1,000 books and articles were written on the subject. The number of publications rose to more than 10,000 before 1910.

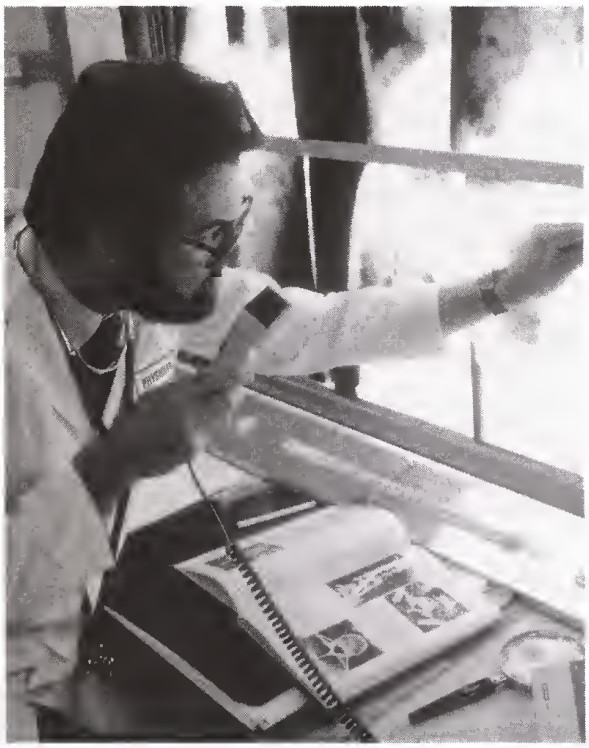
A Diagnostic Tool

The penetrating power of X-rays to reveal bone structure was immediately recognized as a new medical diagnostic tool. Not all the excitement was positive, however. Many people considered the X-ray machine's ability to look through walls and doors an end to privacy. In fact, opera houses banned the use of X-ray binoculars in order to prevent patrons from peering beneath the actresses' costumes. Nevertheless, more rational minds eventually prevailed. Roentgen was awarded the first Nobel Prize for Physics in 1901.

Practical Uses of X-rays

The first medical use of X-rays came in 1896. It was American physiologist Walter Bradford Cannon who used a fluorescent screen to follow the path of barium sulfate through an animal's digestive system. This was possible only after Thomas Alva Edison invented the X-ray fluoroscope that same year. Soon after, physicians worldwide began using X-rays on humans, usually to examine bone fractures or to search for foreign objects such as bullets.

A doctor examines x-rays. By 1970 most Americans were receiving at least one X-ray exam every year from physicians and dentists



By 1970 most Americans were receiving at least one X-ray exam every year from physicians and dentists. However, recent evidence has shown that overexposure to X-rays can lead to the development of leukemia. Many doctors now recommend X-ray exams only when absolutely necessary

Ironically, the harmful side effects of X-ray scanning have suggested yet another use for the procedure called **radiotherapy.** In this therapy, very high frequency X-rays ("hard rays") are used to destroy cancer cells. Radiotherapy is most often used in conjunction with **chemotherapy** (cancer medicine that is taken by mouth).

X-Rays in Everyday Life

One of the most familiar X-ray machines is the baggage scanner found at airport terminals. This low-power X-ray device is placed over a

conveyor belt, where it scans passengers' luggage. The machine used in this type of scanner must operate at a very specific frequency. It must be high enough to penetrate hard-shell baggage but low enough to prevent the accidental exposure of camera film.

[*See also* **Barium; X-ray crystallography; X-ray machine**]

X-ray crystallography

X-ray crystallography was first developed as a means of determining the nature of **X-rays** themselves. It was not intended to be a research tool. In crystallography X-rays are used to probe the structures of crystals. The pattern of diffracted X-rays is similar to an atomic "shadow." By examining where the X-rays are blocked by the crystal's atoms, scientists can define the structure of those atoms.

Medical Uses for Crystallography

Perhaps the most important application of X-ray crystallography is its use in synthesizing (blending) substances. Many of the medicinal chemicals that have been discovered by scientists are very difficult to produce naturally in large amounts. When this happens, it becomes necessary to create the chemicals in the laboratory through synthesis. Before a chemist can synthesize a substance, a map of its atomic structure must be obtained. This map can only be drawn by using X-ray crystallography.

Few scientists have been more successful at this than British chemist Dorothy Hodgkin (1910-). During World War II (1939-1945), Hodgkin and her colleagues determined the structure of **penicillin.** The synthesis of this drug was necessary for mass wartime production. Since then Hodgkin's team has worked on the mapping of **vitamin B12,** the vitamin prescribed to prevent pernicious anemia (a chronic blood disorder characterized by weakness and pallor). The team also worked on mapping **insulin.** Insulin is used in the treatment of diabetes (another blood disorder).

Other researchers have used X-ray technologies to record the structures of proteins, hemoglobin, and the double-helix of DNA structure (deoxyribonucleic acid).

Creating a New Science

The development of X-ray crystallography also created the science of mineralogy. Once the inner structures of many minerals were determined, mineralogists were able to define the major mineral groups. The

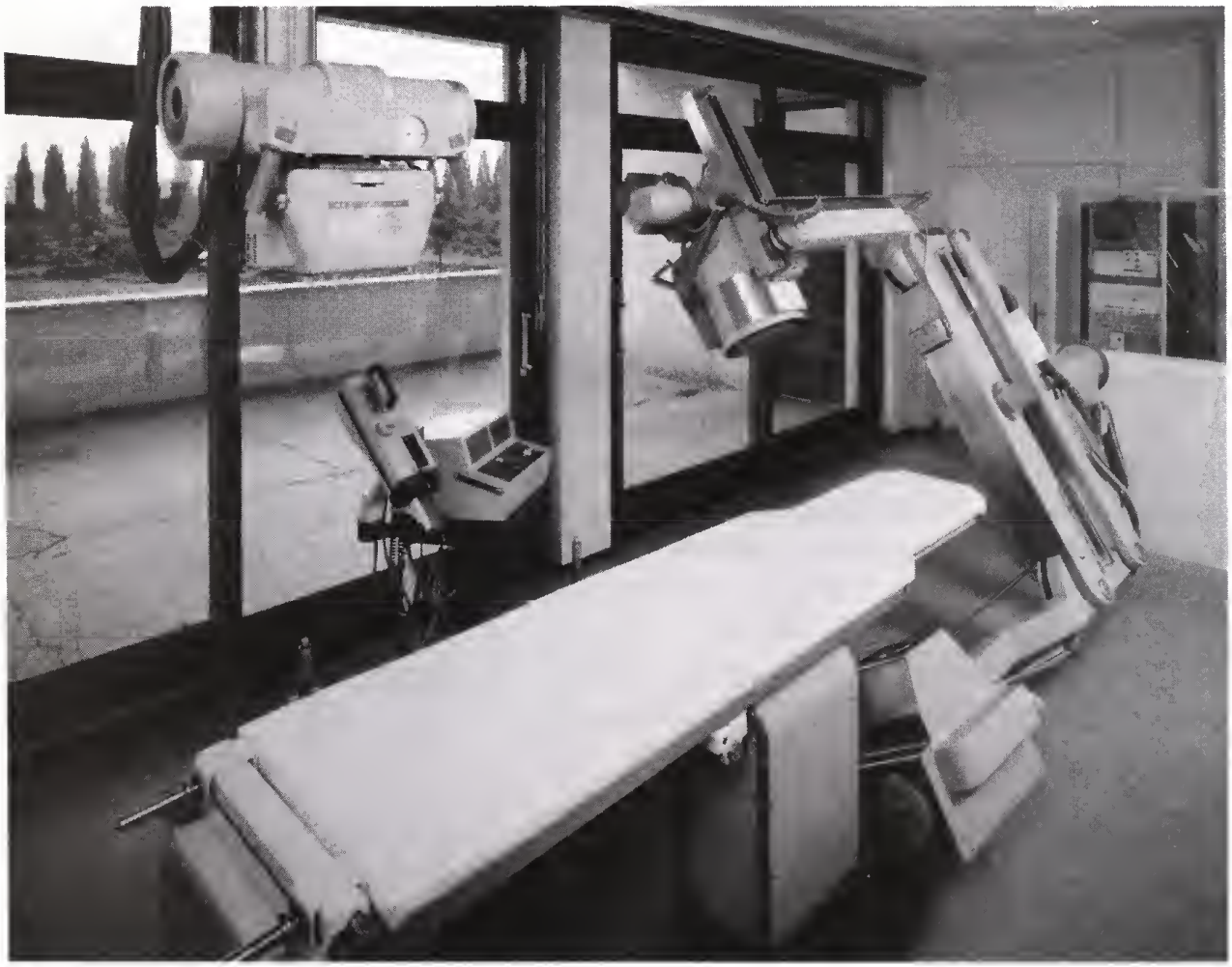
understanding that stems from crystallography has also allowed scientists to construct the man-made minerals used in industry.

[*See also* **Barium; Bragg, William Henry and William Lawrence; Coolidge, William; Radiotherapy**]

X-ray machine

The first **X-ray** device was discovered accidentally by the German scientist Wilhelm Roentgen (1845-1923) in 1895. He found that a cathode-ray tube emitted invisible rays that could penetrate paper and wood. The rays caused a screen of fluorescent material several yards away to glow. Roentgen used his device to examine the bone structure of the human hand. This

A modern x-ray unit.



What Are X-rays?

X-rays are waves of electromagnetic energy. They behave in much the same way as light rays, but at much shorter wavelengths. When directed at a target, X-rays can often pass through the substance uninterrupted, especially when it is of low density. Higher density targets (like the human body) will reflect or absorb the X-rays. They do this because there is less space between the atoms for the short waves to pass through. Thus, an X-ray image shows dark areas where the rays traveled completely through the target (such as with flesh). It shows light areas where the rays were blocked by dense material (such as bone).

machine was really just a modified cathode-ray tube. True X-ray machines were not invented for several years.

Upon their discovery in 1895, X-rays were advertised as the new scientific wonder and were seized upon by entertainers. Circus patrons could view their own skeletons and were given pictures of their own bony hands wearing silhouetted jewelry. Many people were fascinated by this discovery. Some people, however, feared that it would allow strangers to look through walls and doors and eliminate privacy.

Medical Use of X-rays

The most important application of the X-ray has been its use in medicine. This importance was recognized almost immediately after Roentgen's findings were published in 1895. Within weeks of its first demonstration, an X-ray machine was used in America to diagnose bone fractures.

Thomas Alva Edison invented an X-ray fluoroscope in 1896. American physiologist Walter Cannon used Edison's device to observe the movement of **barium** sulfate through the digestive system of animals and, eventually, humans. (Barium sulfate is a fine white powder that is still used as a contrast medium in X-ray photography of the digestive tract.) In 1913 the first X-ray tube designed specifically for medical purposes was developed by American chemist **William Coolidge** (1873-1975). X-rays have since become the most reliable method for diagnosing internal problems.

Modern X-Ray Machines

Modern medical X-ray machines have been grouped into two categories: those that generate "hard" X-rays and those that generate "soft" X-rays. Soft X-rays are the kind used to photograph bones and internal organs. They operate at a relatively low frequency and, unless they are repeated too often, cause little damage to tissues.

Hard X-rays are very high frequency rays. They are designed to destroy the molecules within specific cells, thus destroying tissue. Hard X-rays are used in **radiotherapy,** a treatment for cancer. The high voltage necessary to generate hard X-rays is usually produced using cyclotrons or synchrotrons. These machines are variations of particle accelerators (atom smashers).

One of the more familiar X-ray machines is the security scanner used to examine baggage at airports. These machines use a very low-power scanner. They illuminate the interior of purses and suitcases without causing damage to the contents.

[*See also* **Bragg, William Henry and William Lawrence; Insulin; Penicillin**]

Zeiss, Carl

Carl Zeiss (1816-1888) was both an inventor and industrialist. Zeiss was born in Germany and educated in medicine, but he soon showed an interest in microscopes. Eventually he started a company called Zeiss Optical Works in Jena, Germany, that built specialized lenses for research equipment. Along with his partner, **Ernst Abbe** (1840-1905), Zeiss helped set design standards for medical glass that still stand today. For the microscope, Zeiss invented the apochromatic lens, which improved its focus.

Zygote intrafallopian transfer

Zygote intrafallopian transfer (ZIFT) is a variation on a procedure called **in vitro fertilization.** With in vitro fertilization, an egg is fertilized in the laboratory in a glass petri dish. After the egg has been fertilized it is returned to the womb. Once in the womb, the fertilized egg starts to divide and then develops as any other fetus.

The zygote transfer is a bit different. A zygote is a fertilized egg before it starts to divide. In this procedure, the eggs are fertilized in a petri dish. They are transferred into the fallopian tubes of the mother. Once in the mother, the zygote begin their natural division process. The difference between the two procedures is very slight.

Master Index

Italic type indicates volume numbers
Boldface type indicates entries and their page numbers
(ill.) indicates illustrations

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

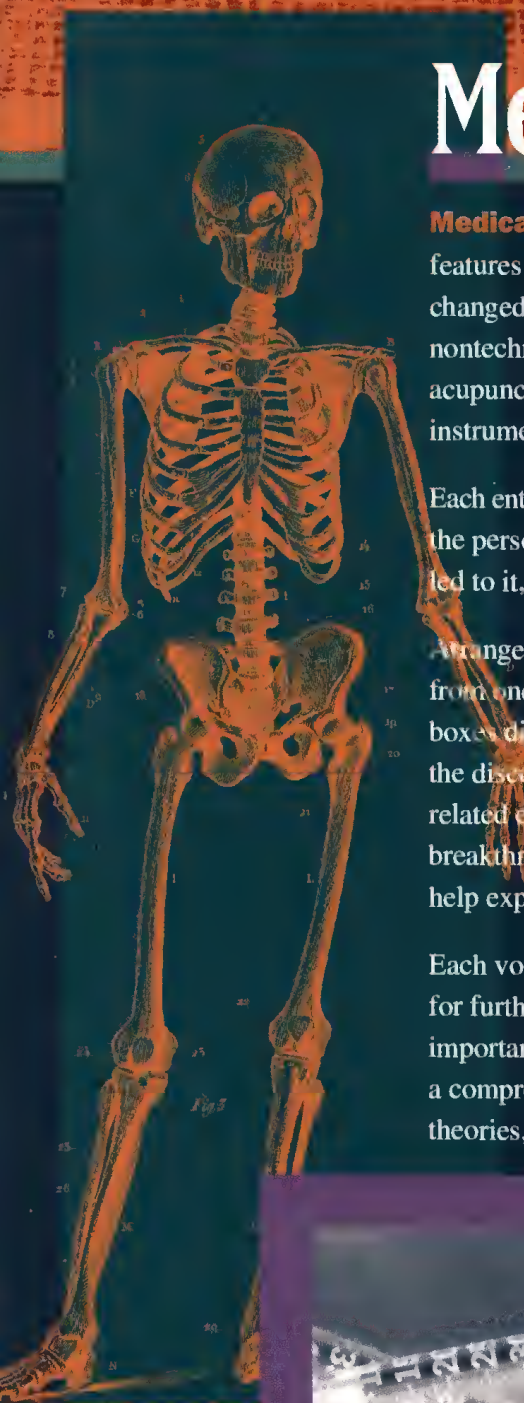
V

W

X

Y

Z



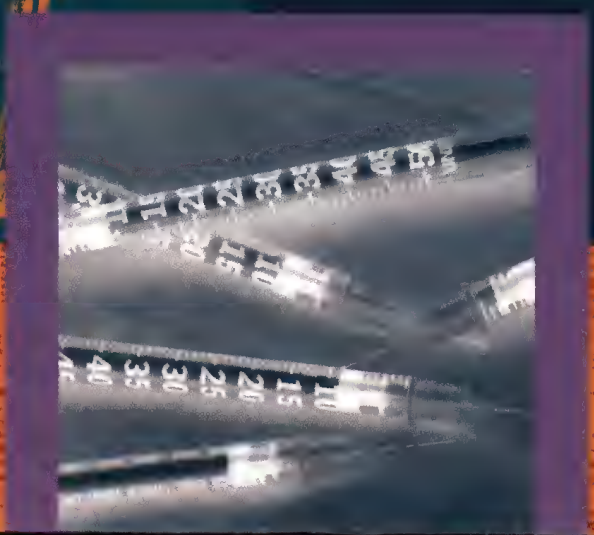
Medical Discoveries:

Medical Breakthroughs and the People Who Developed Them features 215 medical and dental inventions and discoveries that have profoundly changed the way diseases are diagnosed and people are treated. Written in nontechnical language, *Medical Discoveries* explores medical practices such as acupuncture, significant developments in research such as chemotherapy, and instrumentation such as the X-ray machine.

Each entry, whether on a well-known discovery or lesser-known invention, identifies the person behind the breakthrough, explores the knowledge and technology that led to it, and explains how the advance changed the world in which we live.

Arranged alphabetically over three volumes, *Medical Discoveries'* entries range from one-quarter to six pages in length. Accompanying several entries are sidebar boxes discussing related topics and items of special interest to students, such as the discovery of DNA structure. Boldfaced terms in the text direct students to related entries, while cross-references at the end of entries direct readers to other breakthroughs that might be of interest. More than 150 photographs enliven and help explain the text.

Each volume opens with a further readings page that directs students to sources for further study, a timeline of medical and dental landmarks, and a glossary of important medical and dental terms found in the text. The volumes conclude with a comprehensive general index that allows students quick access to the people, theories, and inventions discussed in *Medical Discoveries*.



U·X·L®
AN IMPRINT OF GALE

ISBN 0-7876-0893-9
90000
9 780787 608934